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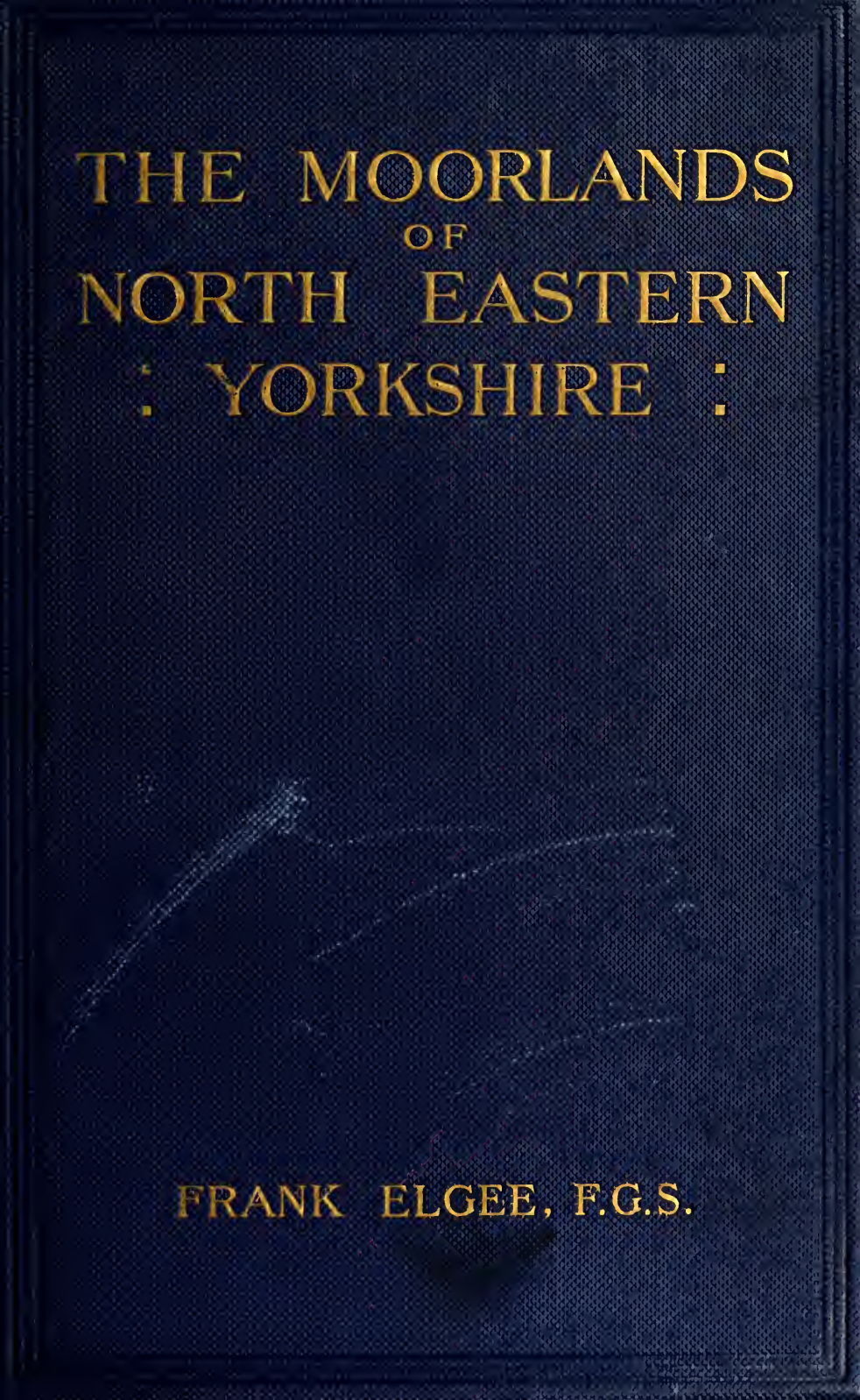

FRANK ELGEE, F.G.S.

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THE MOORLANDS
OF NORTH-EASTERN YORKSHIRE

Photo by] NEWTON DALE. *[Frank Elgee.*

THE MOORLANDS OF NORTH-EASTERN YORKSHIRE

Their Natural History and Origin

BY

FRANK ELGEE, F.G.S.

LONDON

A. BROWN & SONS, LTD., 5 FARRINGDON AVENUE, E.C.

AND AT HULL AND YORK.

1912.

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PREFACE

IN this work I have gathered together the results of over fifteen years' research into the botany, geology and zoology of the Eastern Moorlands of Yorkshire. So far as I am aware, it is the first English book which deals with the moors of a district from a scientific standpoint and which treats of their varied phenomena as a coherent whole. Moors in different parts of Great Britain have been botanically considered in papers by the members of the Central Committee for the Survey and Study of British Vegetation, Drs. W. G. Smith, Moss, Rankin, F. J. Lewis, and the late R. Smith. In Tansley's "Types of British Vegetation" (1911), moors and heaths are considered in relation to other types of vegetation and to their conditions of existence, climate, soil, etc. On the Continent, they have long been recognised as important objects of research, and there are innumerable books and papers concerning them, among which may be mentioned Graebner's "Heide Nord-Deutschlands," and Schröter and Früh's "Moore der Schweiz." But this work differs from all these in that it considers not only the plant life of the Eastern Moorlands, but also the geology and zoology in their relationship and interdependence.

It may be as well to direct attention to certain sections of the work which deal with aspects and problems of the moors hitherto overlooked, or merely hinted at by earlier workers: the peat beds and the evidence they yield as to primitive woodland on the moors; the relationship of the moorland fauna and flora to the glaciation of the district; the origin of the chief moorland land-forms,

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especially outliers like Roseberry Topping, and inliers like the Hole of Horcum ; the fauna of the moors and its relation to the flora. Problems of more general interest here discussed are, the conditions which determine the existence of moors ; the origin of the moorland flora ; the origin of the Red Grouse ; the origin of the insect life, particularly the Butterflies and Moths. I have approached each problem independently, and have, in each case, drawn my conclusions from the numerous data my investigations have afforded. Much still remains to be done before our knowledge of the Eastern Moorlands can, in any way, be regarded as complete. Those who have explored the district will understand how arduous a task it is to examine thoroughly an area nearly as large as an average English county, and intersected by innumerable valleys, each of which possesses its peculiarities. Perhaps the investigation of the peat deposits, layer by layer, is the most urgent piece of research that is needed, not only because it would furnish indications of climatic changes in post-glacial times, but also on account of the light it would throw on the development of the Mosses, our knowledge of which at present is largely inferential.

As every aspect of the Eastern Moorlands has been touched upon in these pages, an exhaustive treatment of each topic has not been attempted. General characteristics alone have been described. Detailed descriptions of moorland plants and animals have been purposely avoided, as such can be found in works specially devoted to accounts of the British flora and fauna. My aim throughout has been to trace the moors to their causes ; to indicate the interaction and interdependence between the animals and plants, and the geological history of the district.

The book is an expansion of my paper on the " Origin of the Cleveland Moors," read before the Cleveland Naturalists' Field Club in February 1907, and afterwards published as a pamphlet. It will also be found to contain a more elabor-

ate exposition of the leading ideas in my paper on " The Driftless Area of North-Eastern Yorkshire and its Relation to the Distribution of Certain Plants and Animals " published in " The Naturalist " for April, 1907 ; and in my paper on " Glacial Survivals," which appeared in the same journal for August and September, 1907. The zoological section of the work, particularly the part dealing with the insect life, is coincident with my paper on the " Problems of the Fauna of North-Eastern Yorkshire," read before the Yorkshire Naturalists' Union at Northallerton in August 1908.

I offer my best thanks to Mr. Godfrey Bingley of Leeds, for those photographs which he has kindly allowed me to utilise, and to Mr. Wray of Goathland, for the photograph of Lilla Cross. The rest of the illustrations have been taken by myself, and include views of many out-of-the-way localities, such as Loose Howe, Bloody Beck, Yarsley Moss and Winter Gill.

The two coloured maps are based on those of the Ordnance Survey (supplemented and confirmed by my own observations) with the permission of the Controller of H.M. Stationery Office, to whom I tender my thanks, and to whom I am also indebted for permission to quote short excerpts from the Memoirs of the Geological Survey. The small maps are intended to convey an idea of the distribution of some familiar moorland plants and animals, and must be regarded as merely approximate. Anyone who has plotted out distributions as given in monographs must often have been struck by their vagueness. An insect is stated to be found in all Europe, but does this include Iceland and Greece, Lapland and the Ural Mountains, Portugal and Turkey in Europe ? Still vaguer does the distribution become when a species is said to inhabit North America or North Asia.

To the subscribers my very best thanks are due for their invaluable support in this undertaking, since without it I should have been unable to publish. I regret that there

has been so long a delay in the publication of the work, but this was partly owing to the difficulty of obtaining a sufficient number of subscribers, and partly to unavoidable delays contingent on seeing the work through the press.

I am also greatly indebted to my father, Mr. T. C. Elgee, for invaluable help and suggestions during the preparation of the work. To Miss Harriet Wragg, B.A., of Shirley, Warwickshire, I must here express my best thanks for many suggestions and for assistance in correcting proofs.

I ought also to add that the illustration of the Red Grouse has been made from Scotch birds in the Middlesbrough Museum, to the Curator of which, Mr. B. Hudson, I am obliged for permission to photograph the same.

FRANK ELGEE.

MIDDLESBROUGH, *December* 1912.

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Photo by] FIG. 1.—NEWTON DALE FROM SALTERSGATE BECK. *[Frank Elgee.*

Moorlands of North-Eastern Yorkshire

INTRODUCTION

NORTH-EASTERN Yorkshire has long been regarded as one of the most picturesque and interesting districts of England, particularly on account of its beautiful dales and wide-spreading heather-clad moors, so much frequented by the sportsman, the holiday-maker, and the tourist. It has also been a favourite region for the investigations of the antiquary, the botanist, the geologist, and the naturalist; but hitherto no comprehensive account of its moorlands in their scientific aspects has been given. This hiatus in our knowledge of the area it is proposed to fill by the present work, which deals exclusively with the moors as an object of research, and describes their plant-life, geology, and natural history, with a view to elucidating the problem of their origin.

The geographical features of North-Eastern Yorkshire have so often been described that it will suffice for the benefit of those unacquainted with the district if we indicate in a general way the distribution and boundaries of the moorlands and their relation to the topography, since further details will appear in the course of the work.

The region forms one of the most natural divisions of Yorkshire, possessing its own special physical and geological features, and being well-defined by distinct physical boundaries. In a general sense the district is an elevated table-

land, nowhere attaining a greater altitude than 1489 feet above the sea. In the south, this tableland is separated from the Chalk Wolds by the fertile Vale of Pickering; in the west, it is bounded by the Vale of York; in the north it is defined by the plain of Cleveland, and the lower valley and estuary of the Tees; and in the east, it terminates in the grand sea-cliffs from Saltburn to Scarborough. Within these lines the great moors occur, extending about thirty-two miles from east to west, and sixteen miles from north to south, and containing between three hundred and four hundred square miles of land more or less covered with Heather.

We may regard the Eastern Moorlands as an irregular, dome-shaped *massif*, the north-western portion of which, formerly occupying the lowlands of the Vale of Stokesley, has been swept away. This *massif* reaches its highest elevation of 1489 feet at Burton Head on Urra Moor, above Ingleby Greenhow. Burton Head is not placed in the centre of the tableland; on the contrary, it is situated towards the western margin, and the adjacent heights do not differ considerably from it in elevation. Eastwards from Urra, the moors extend in an almost unbroken line to Peak, the south point of Robin Hood's Bay, and form the back-bone of North-Eastern Yorkshire, the South Cleveland or central watershed, which divides the drainage of the Esk from that of the Derwent. From 1489 feet on Urra Moor to 800 feet on Brow Moor at Peak, there is a decline of 689 feet in twenty-six miles. From Urra Moor to Cock Heads on Glaisdale Moor, the highest points are, Stony Ridge, 1422 feet; Farndale Moor, 1342 feet; Ralph Cross, 1409 feet; Loose Howe, 1419 feet (Fig. 40); and Cock Heads, 1301 feet; a total fall of about 200 feet in nine miles. East of Cock Heads, the watershed rapidly declines in height, being 1070 feet on Egton High Moor, 824 feet on Goathland Moor, and 959 feet at Lilla Cross on Fylingdales Moor (Fig. 70).

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Westwards from Burton Head, the elevation of the Cleveland Hills steadily sinks until, above Osmotherley, it is about 1050 feet, a fall of 439 feet in seven or eight miles. South of the central watershed, the tableland slopes gradually to the Vale of Pickering, interrupted, however, by the great range of the Tabular Hills, whose flat-topped summits also slope down to the Vale. North of the central watershed, the plateau descends to the valleys of the Esk and Kildale—a remarkable trough running through the uplands from the Cleveland escarpment at Kildale to the sea at Whitby. Between Guisborough and Aislaby (near Whitby), the moors cover the high land north of Eskdale, the North Cleveland watershed, though their boundary is not always defined by any well-marked physical features. They comprise the chief moorlands of Cleveland properly so-called, and are comparatively unbroken by cultivated valleys, except at the western end, where Lonsdale and Sleddale fall into Kildale, and at Stonegate between Lealholm and Glaisdale (see map).

Between Whitby and Scarborough, the moors cover the high ground which terminates in the sea-cliffs, but their boundary as a rule falls short of the sea, except at Peak, where the Heather descends almost to the shore. In this area, the moor edge coincides with the uppermost slopes of the valleys converging on Robin Hood's Bay, Hayburn and Cloughton Wykes ; and at Hackness and Seamer, they exist upon the summits of the Tabular Hills.

In the south, the margin of the moors follows, more or less closely, the escarpment of the Tabular Hills which, facing north and commanding the chief moorland region, runs across the country from Scarborough to Black Hambleton in the west (for views of the Tabular Hills, see Figs. 45, 46, 47, 49, 50, also frontispiece where the flat-topped nab in the right background is part of this range). The course of this noble range is clearly indicated on the geological map by the pink band north of the blue. A comparison

of the two maps shows that the moors overlap the summit of the escarpment, and in places form extensive spreads on the flat tops. This feature is especially noticeable in the neighbourhood of Lockton, Levisham, Allerston, and Dalby in the east ; and further west at Boonhill Common, Birk Nab, and near Rievaulx.

The western end of the moors coincides with an extension of the same range of hills, forming the grand escarpment of the Hambletons which overlooks the Vale of York and the towns of Thirsk and Northallerton. The Hambletons extend from Roulston Scar in the south, to the summit of Black Hambleton and Arden Great Moor in the north ; the former at an altitude of 900 feet, the latter at an altitude of 1289 feet. From Roulston Scar the moors trend eastwards, in an irregular manner, to the valley of the Rye near Helmsley, which, with its branches, forms a large area of cultivated country almost surrounded by moorlands.

A glance at the map shows that the moors are by no means continuous within these natural bounds, but are broken up into larger and smaller areas separated from one another by deep valleys—the dales. The dales south of the central watershed are much longer and larger than those to the north, and taking them from west to east they are, Ryedale, Bilsdale, Bransdale, Farndale, Rosedale, and Newton Dale. Those falling towards the valley of the Esk are Baysdale, Westerdale, Danby Dale, Great and Little Fryup Dales, Glaisdale, Egton Grange, Goathland Dale, and Iburndale. The moorland ridges between these valleys are usually somewhat narrow, but often expand as they recede from the watershed. This is particularly the case with the ridges between the great southern valleys of Bilsdale, Bransdale, Farndale, and Rosedale : the moors upon them unite at the foot of the Tabular Hills, and extend almost uninterruptedly from Helmsley Moor to Wykeham High Moor, and to the heights above Cloughton and Burniston.

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The greatest expanses of unbroken moor occur in the east. The tract of high land between Rosedale and Newton Dale, constituting Egton High, Wheeldale and Pickering Moors, is one of the largest spreads of heath vegetation in North-Eastern Yorkshire. Joining this group of moors is another group, which, as the map clearly indicates, is by far the widest and most continuous part of the whole moorland area—that east of Newton Dale; Goathland, Sleights, Fylingdales, Allerston, Wykeham High, and Ebberston High Moors. The most striking feature of this area is the general easterly trend of its small valleys, a trend in agreement with the easterly slope of the land. These small dales constitute the valleys falling into Robin Hood's Bay, Staintondale, the Symes Valley, the valleys of Black Beck and the Derwent, and Troutsdale. The three latter coalesce and form the Sea Cut valley between the heights of Hackness and Irton Moors.

Such then, in brief outline, is the topography of the district we shall study in these pages; further details of the utmost importance will appear in the course of this work but an attentive examination of the maps will enable the reader, without difficulty, to grasp the essential features. It must be remembered that we shall use the word " moor " in its local sense, as a convenient term for all heather-clad land, heaths, moorland bogs, and even in some cases grassy commons. The term " heath " perhaps best describes the larger portion of the Eastern Moorlands, but it is an unfamiliar word in the North of England. " Moor " in some parts of the country, and always in Germany, is applied to swampy land or bogs whether they are clothed with heath vegetation or not. Such a restricted use of the word in the present instance would not only be inconvenient, but misleading. If it is always borne in mind that we use the word as it is employed in the district, no confusion of ideas can possibly arise.

It is somewhat surprising that the moors have not

received the attention which they certainly deserve. The moor problem is essentially a botanical problem, but even from this standpoint, it has received scant notice. True it is that we have more or less complete lists of the flora, but any attempt to study the "moor" itself does not appear to have been made. The nearest approach was that of Mr. J. G. Baker, F.R.S., in his "North Yorkshire: Studies of its Climatology, Geology, and Botany," published in 1863, and re-issued in 1906, by the Yorkshire Naturalists' Union. In this work, as its title indicates, the author was the first to endeavour to trace the relationship which subsists between the plant life of North Yorkshire and its geology and climate, and in the floristic part of the work, the range and status of the moorland plants are carefully described. The topography of the district is also delineated in some detail, but there is no actual account of the moors, though the work contains a description of the vegetation of Rombald's Moor near Ilkley, in which the author very closely approaches the modern conception of the plant association. "North Yorkshire" is a great pioneer work, and an indispensable source of valuable information concerning the flora and the abundance or rarity of its component species. As such, we have frequently employed it whilst developing the present work.

One of the earliest descriptions of the moors is to be found in Marshall's "Rural Economy of Yorkshire" (1796), where not only is there a list of plants, but also an account of the moorland soils (see Chapter III.).

Dr. Young, in his "History of Whitby" (1818), mentions May Moss as a remarkable upland bog, and it is probably this moor which is called the "Moss" in several of the charters of Whitby Abbey (*temp.* Henry I.). It is first mentioned in a grant of Alan de Percy to the Abbey of Whitby, where it states: "I have given and confirmed to the aforesaid church of Wyteby, and to the monks performing divine service there, for a perpetual alms, all the

lands, forests, pastures, and woods in my freehold . . . within these boundaries, viz., all the sea-coast from the port of Wyteby to Blawych (Blue Wick or Blea Wyke), and thence to Grenedic (Green Dyke near Peak); and along Grenedic to Swinestischage, and to Thornelay, and all Thornelay; and to Kirkelac (Kirkless near Burniston), and to Coppekeldebrok, and thence along by the brow of the hill beyond Theovesdiches (Thieves' Dykes on Suffield Moor) to Staincrossegate, which is near the town of Suffield; and thence to Gretaheued, and to Elsicroft, and the Moss (*Mosam*) to the middle of the Moss; and thence to the Derewent, and half the Derewent all along to where the Derewent first rises out of the earth, and to Lilla Cros, and to Scograineshoues (probably Louven Howes), and to Sylhou (Sil Howe on Sleights Moor), etc."* We have quoted this charter because it mentions several places on the moors, and is perhaps the earliest reference to them.

The geology of the Eastern Moorlands has attracted attention ever since the close of the eighteenth century, and thanks to the labours of many enthusiastic students we now possess a tolerably complete knowledge of the stratigraphy of the area. Young and Bird's "Geological Survey of the Yorkshire Coast" (1828), contains brief references to the moors and their rocks, but the late John Phillips, in his "Illustrations of the Geology of Yorkshire" (1829), first described and indicated the geological position of the moorland strata. To him, also, we owe the name "Tabular Hills," whilst in the "Sea-Coast, Rivers and Mountains of Yorkshire" (1855), he discussed the causes which have led to the formation of the moorland *massif* and its dales.

The late Joseph Bewick, the mining engineer of Grosmont, in his "Geological Treatise on the District of Cleveland" (1861), gives the following entertaining description of the moorland pass between Commondale and Kildale:—"This

* Charlton's "History of Whitby," 1779.

deep glen, which owes its origin to the occasional violence of mountain streams, is excavated through a large tract of high moorland; its slopes can only boast of a scant vegetation, whilst the surface of its high ridges is thickly studded with the purple heath, through which protrude rough and rugged blocks of sandstone. In this still and secluded valley, you might well suppose you were 'out of humanity's reach,' were it not that you see before you the railway twisting its serpent-like form round the projecting portions of the hills by the side of the stream. The hissing, puffing, and rapid motion of the wonder-working locomotive along this dell, at once tells you that industry and enterprise have reached this bleak and desolate region. These large tracts of moor waste do little more than afford shelter and sustenance to the wild moor fowl, which, in your moorland rambles, is ever rising before you, uttering his well-known note, and with rapid flight gracefully skimming the surface of the heathery heights, whilst their rocky interior teems with minerals more valuable than gold."

It is to the officers of the Geological Survey that we owe our most accurate knowledge of the moorland strata, and in the series of maps and memoirs dealing with North-Eastern Yorkshire, we have an invaluable store of authentic data for the solution of the various problems presented by the geology of the district. In 1892 appeared the late Mr. Fox-Strangway's monograph on the "Jurassic Rocks of Yorkshire," which, besides gathering together the results obtained by earlier workers and the Survey, also gives a brief description of the Eastern Moorlands from an agricultural point of view. The author also deals with the scenery of the district and its origin. Moreover, the Survey was the first to give information on the peat deposits of North-Eastern Yorkshire, and frequently in the sheet memoirs the officers refer to the vegetation of the moors.

The Sedgwick Prize Essay of the University of Cambridge in 1900 was Mr. F. R. Cowper Reed's "Geological History

Photo by] FIG. 2.—NEWTON DALE FROM PIFFEL HEAD. *[Frank Elgee.*

Photo by] FIG. 3.—HIGH STONE DYKE, CASTLETON RIDGE. *[Frank Elgee.*

of the Rivers of East Yorkshire," which, though not dealing with the moors, is, nevertheless, of invaluable assistance in enabling us to understand the origin of their scenery.

Another very important advance in our knowledge of the Eastern Moorlands was made when Professor P. F. Kendall, of the Leeds University, published his " System of Glacier Lakes in the Cleveland Hills " in the Quarterly Journal of the Geological Society for 1902. This paper, apart from the special problems it elucidates, has been of great service in settling the conflicting opinions with regard to the Ice Age so far as it concerns the district, a geological period, which, as we shall hereafter see, is of the utmost significance in the botanical and zoological history of the moorlands.

In 1911, Dr. W. G. Smith gave a brief account of the vegetation in Tansley's " Types of British Vegetation," the first actual account of the moors as such that has hitherto appeared. Dr. Smith, as a member of the Central Committee for the Survey and Study of British Vegetation, has botanically surveyed North-Eastern Yorkshire, but his results have not yet been published. It should be here added that Dr. W. G. Smith's brother, the late Robert Smith, began the botanical survey of this country by recording the different types of vegetation (moors, fens, woods, etc.) upon maps showing the distribution of the various plant-associations.

Before beginning our account of the Eastern Moorlands, it will be as well to lay before the reader some idea of the method and scope of this work, in order that he may be better able to follow its argument.

A detailed description of the antiquities of the moors does not fall within the compass of these pages. Nevertheless, as the human aspects are the first to attract notice, we shall briefly survey the roads, stones, crosses, howes and other objects, many of which date back to early times, and yield indications of the state of the moorlands at the time of their construction.

The most salient feature of the moors is their plant life. Consequently, this will next receive attention, not from a floristic but from an ecological standpoint. That is to say, instead of giving a list of species found in various localities, we shall describe how the species are grouped together to form different types of moors—Heather Moor, Cotton Grass Moor, Grass Moor, etc., their distribution and their conditions of life. The ecological method of studying the plants necessitates an investigation into the character and origin of moorland soils, the growth and formation of peat beds, and the development of moors. In this section of the work, special attention will be devoted to the interesting problem as to whether the Eastern Moorlands were ever covered with woods and forests.

We shall then pass to a consideration of the Ice Age, since that great geological episode has had a profound influence upon the history of the moorland fauna and flora, and has left traces of a most striking and unique character in the scenery of North-Eastern Yorkshire. A clear comprehension of that epoch will prepare the way for a discussion on the origin of the principal moorland plants, which will be reached by an examination of their geographical distribution and geological history.

We shall next turn to the geological history of the district, one of the most potent factors in determining the origin of the moors. First, we shall glance at the nature of the moorland rocks, and observe the influence they have upon the vegetation. An attempt will also be made to indicate the causes which have resulted in the present scenic features of the uplands: the formation and origin of the *massif*, the great dales, and those picturesque ranges, the Cleveland, Hambleton, and Tabular Hills.

Finally, we shall treat of the animal life or fauna of the moors, so far as present knowledge will allow. In this section, the haunts and habits of moorland birds and insects, their history and origin, and their effects upon and relation

to the plant life will be examined. We shall pay special attention to the problem of the origin of the Red Grouse, and its remarkable changes of plumage.

The scope of this work is to exhibit the *interdependence* of all aspects of the moors : their antiquities, plants, rocks, insects, stones, birds, and climate form a coherent whole which cannot be fully understood unless all are considered. We shall regard the moors as a unique assemblage of factors of intense interest, which owe their present status to innumerable causes that have been operating for ages. In other words, we shall follow that sequence of events which has led to the evolution of the moorlands of North-Eastern Yorkshire.

CHAPTER I

BLACK-A-MORE

OF the many approaches to the moorlands of North-Eastern Yorkshire, the grandest and most impressive is through Newton Dale. Leaving the old town of Pickering for Goathland or Whitby, the traveller from York, whose journey has just made him acquainted with the fertility of the Vale of Pickering, soon finds himself in a totally different region. The low-lying plain of the Vale with its distant hills is almost immediately succeeded by the deep, narrow gorge of Newton Dale, which, towards the north, penetrates into the heart of that elevated tract of country sometimes spoken of as the Eastern Moorlands, and referred to by Camden in his "Britannia" (1607), in the following words:—"That which lieth east and towards the sea is called Black-a-more, that is the black moorish land."

Passing northwards, Newton Dale gradually increases in depth, and from being a well-cultivated valley in its lower reaches, becomes in its higher parts a scene of wildness and grandeur. The flat floor of the gorge, and the steep sides clothed with great woods of Pine, Oak and Birch, are traversed by no regular road. Occasional areas of cultivation, scattered cottages, and rough footpaths by the railway, indicate even to-day the isolation and comparative impenetrability of this great valley—the gateway to the moors (see frontispiece). At the old mill of Raindale, the gorge which has so far trended almost due north for eight miles begins to wind in a series of immense curves. On the western side, below a great wall of precipitous sandstone cliffs, a steep and irregular slope of debris covered with a broken scrub rises from the floor to an elevation of two or

three hundred feet. On the eastern side there are similar slopes, similar mural precipices in the form of bold nabs, but above the latter towers the impressive, flat-topped escarpment of the Tabular Hills, though not at this point forming the immediate side of the dale. The heart of the moors is reached here ; all signs of cultivation have disappeared ; we are at the head of the valley, at Fen Bogs. Its floor is swamp and morass ; its slopes are almost vertical ; streams fall over the cliffs ; and cañon-like, Newton Dale cuts through the wide spreading moors of Goathland (Figs 1 and 2).

Let us ascend the steep slopes of the valley—on reaching the summit, the great moorlands, on which so many storms have beaten, and on which so many sunsets have glowed, lie in every direction, impressive in their elevation, their vegetation, and the manner in which they are intersected by deep, cultivated dales. At once we are under the influence of those ampler spaces that we have lost sight of in the narrow ways of cities. We renew a spirit of freedom born of the open sky, the pure air, and the uninhabited land.

To the student of nature these heather-clad wastes possess a fascination and interest of an unusual kind. Although woods, fields and lanes have their own peculiar charms, they have not the special charm of the moors. In the former, man has altered the primitive aspects of the country to a very considerable extent. Not so with the moors which for long periods have been comparatively little interfered with, and where we find animals and plants living under natural conditions. They have not remained entirely unchanged ; roads have been made across them ; they are used as game preserves ; and they are periodically burnt and "graved." But with these exceptions, the moors of North-Eastern Yorkshire still offer some of those original aspects of nature which, in England, are rapidly disappearing with the growth of population and industry.

The most striking feature of the moors is that they are

almost exclusively clothed with one species of plant—Heather. Familiarity with this remarkable phenomenon makes us rather apt to overlook its wonderful character. What are we to think of the moor, that dark heath vegetation with its cold peaty soil enriched only in August by a great robe of purple ? Consider the untold millions of Heather flowers that for thousands of years have bloomed and died on the moors ; it is impossible to conceive or imagine their number. Is it not an extraordinary fact that so large an area should be covered with such a plant carpet ? And how much more astonishing does this phenomenon become when we reflect upon the extensive tracts clothed by Heather, not only in Britain but on the Continent. The very abundance of Heather blinds us to its importance, for as an aspect of plant life, moors are just as remarkable as the vegetation of tropical lands. If, unacquainted with moors, we were told by travellers of extensive regions overgrown with dwarf, shrubby plants, possessing myriads of purple flowers, giving a definite colour to many square miles of the earth's surface, we should express our surprise at their discovery. Yet such is the character of our moorlands, so delightful in their expansiveness, though presenting to the casual observer a general uniformity which veils phenomena of surpassing interest.

Why are the moors so largely covered with Heather and not with trees or other plants ? Why does this vegetation prevail over such wide areas ? What have been the past, and what are the present conditions of life upon these stony uplands ? In other words, what causes the moors ?

A complete reply to these queries cannot be given at the outset, but in some of the most familiar aspects of the moors, such as are likely to attract the attention of anyone who has never previously been upon them, we have indications of their nature, as far back as two or three thousand years ago. Not only shall we comment on these aspects, but we shall keep before us the evidence they yield as to the state

of the heather-clad uplands at or before the dawn of history.

The moors are traversed by characteristic and often very stony roads, the more conspicuous of which undulate through the dark green Heather to the summits of distant riggs, and are thrown by their light colour into vivid contrast with the sombre vegetation (Figs. 7 and 8). From these moorland highways rough cart roads diverge, and in their turn merge into well-defined footpaths that are ultimately lost in obscure sheep walks. We find the evolution of the roads clearly indicated upon the moors, and there can be no doubt that the better class highways have developed in the course of centuries from mere tracks amongst the Heather. When these tracks were first made, we have no means of ascertaining, but a few may, perhaps, be traced back to the Bronze Age, if not to the Neolithic Age. This we infer from the circumstance that some ways travel from one moorland Howe or tumulus of the Bronze Age to another. The most striking instance occurs on Sleights and Widow Howe Moors, where the high road from Whitby to Pickering after leaving Sleights, first passes Flat Howe, Pen Howe, and Bracken Howe. At the latter an old road branches to the south-east by an unnamed tumulus to Robbed Howe, Foster Howes, Ann Cross Howe and Louven Howe to Lilla Howe. Other roads also run past tumuli, which may be either close to the road, or at some little distance from it. Among these may be mentioned the highway from Ingleby Greenhow to Kirby Moorside, which passes Burton Howe, and Three Howes and Obtrusch Rook (a large tumulus) on Rudland Ridge.

We know that the Howes date back to the Bronze Age, probably three thousand years ago, and in some cases even earlier, and being such conspicuous landmarks, they would naturally be selected as points to be gained in crossing the moors, and thus in time a well-defined path would be formed from one burial mound to another. I am inclined, however, to suspect that the original tracks are

older than some of the tumuli, particularly in the case of the old road just described, and that these Howes may themselves have been erected along an ancient Neolithic path. It is not likely that we shall ever be able definitely to trace Neolithic routes over the moors, since within the confines of the Eastern Moorlands, remains of the Neolithic period are scarce.

On glancing at the map we find that north of the river Esk, the highway between Whitby and Guisborough traverses the moors, and roads branch from it into Eskdale. South of this valley there are two first-class moorland roads, one between Sleights and Pickering, and the other between Whitby and Scarborough, together with the following secondary lines of communication between the Eskdale villages and those on the northern side of the Vale of Pickering—Battersby to Kirby Moorside, along Rudland Rigg; Castleton to Kirby Moorside, along Castleton and Blakey Riggs; Danby to Rosedale and Kirby Moorside; Lealholm to Rosedale and Hutton-le-Hole; Egton to Rosedale; Egton to Pickering and others of less note.

As a rule, these roads run along the ridges between the dales, but few of the roads in the latter ascend to the head of the valley and there rise to the moors, though this is the case in Glaisdale. Usually the dale roads branch off from some central point—such as Church Houses in Farndale, and Rosedale Abbey in Rosedale—to join the moor highways; or they circle round the slopes at some little distance from the dale head. The most remarkable feature is the absence of any direct road across the moors from west to east, and, in order to traverse the district in this direction, a circuitous route must be followed. Bearing in mind the principle governing the origin of roads, that they take lines of least resistance, we can understand why those of North-Eastern Yorkshire run as they do. If treeless, the moors would naturally be selected in early times as affording easy routes, and their elevation would

command views of the surrounding country. At a later period, roads would arise in the dales as fast as settlements were established and clearings made; and since the upper parts would probably be the last areas to be brought under cultivation, we have a likely reason why the roads should circle along the slopes around the dale heads.

That the ridgeways have been evolved from ancient tracks is confirmed by the fact that many of them intersect old earthworks, such as High Stone Dyke on Castleton Rigg, shown in Fig. 3. Ancient entrenchments, made of stones and earth, almost invariably cross the ridges dividing the northern dales, and as the roads from Eskdale to the Vale of Pickering follow these ridges, the earthworks are severed by them. One certain inference may be drawn from the position of these earthworks. They indicate that at the time they were erected, the ridges were used for travelling upon, and as lines of military advance. The oldest known moorland road of historic times is Wade's Causeway or "Causey," now disused. Constructed about A.D. 86, during Agricola's command of the Roman legions in Britain, it runs northwards from the Roman Camps at Cawthorn near Pickering, and traverses the Pickering and Wheeldale Moors. The road crosses Wheeldale Gill, skirts the eastern side of the Murk Esk Valley, and probably fords the River Esk near Grosmont. Writing of this road, Mr. Codrington says:—"Wade's Causeway exhibits the gradual destruction of a paved Roman road in operation. On the moors away from 'intakes' or enclosures, the paving is to be found beneath a few inches of soil very much as it was when Roman traffic on it ceased. Where pieces of the moor have been enclosed, the stones of the paving have been taken up for building walls, both from the road within the intake and for some distance outside. On the unenclosed moor enough is left to be mapped as traces of a Roman road, but within the intake cultivation soon obliterates all traces."*

* "Roman Roads in Britain," p. 166.

Furthermore, the Roman road severs an old British earthwork which crosses the moors west of Goathland at Randay Mere (Fig. 30). When the legions threw up their great camps at Cawthorn, it would probably be a moot point with the natives of the dales as to which route the Romans would take over the moors, and it may reasonably be surmised that in order to check their advance, earthworks were erected across the most likely lines of march—the ridges dividing the dales. There is no evidence of any other moorland road being Roman, and this by cutting the old dyke at Randay Mere, supports the opinion expressed by the late Rev. E. Maule Cole, of Wetwang, that many of the Wold entrenchments were erected to oppose the Roman invaders, for they are intersected by the Roman roads.*

The late Canon Atkinson, in "Forty Years in a Moorland Parish," held the view that as a series of defences can be traced from Eston Hills over the north Cleveland moors to the entrenchments in question, they may indicate the advance of some large body of invaders southwards from the Tees. Whether this hypothesis, and Canon Atkinson regarded it as nothing more, be finally verified or not, it is immaterial to the theory we have advanced above. In these pages we are not so much concerned with the identity of the builders of the earthworks as to show that many centuries ago the moors were traversed by roads because they were more or less open and treeless. It is possible that the ancient fortifications date back to pre-Roman times, in which case the ridgeways must necessarily be as old, if not older. Most of the earthworks of North-Eastern Yorkshire require to be investigated before any definite conclusions can be arrived at concerning their origin and purpose.

In some instances, the present roads have changed their position on the ridges during the lapse of centuries. The road along Glaisdale Rigg from Lealholm to Rosedale Abbey, has parallel to it on its eastern side an old way sunk into

* Proceedings of the Y.G.S., Vol. XI., 1888, p. 49.

the moor and overgrown with Heather, the ancient guide stones still standing near the neglected track.

Other causeways, often paved with stones, Canon Atkinson considered to be of considerable antiquity as they lead to the Bow Bridges across the Esk. For example, Pannierman's Causeway traversing Danby Low Moor, leads to Danby Castle Bow Bridge, or to the now destroyed Castleton Bow Bridge, both of the fourteenth century. A bridle path on Moorsholm Moor, the Quaker's Causeway, is so named because it was much used by the followers of Fox in travelling from Guisbrough to Castleton in the early days of the last century.

From early times the course of the moorland roads has been indicated by standing stones, especially where branch roads diverge, though now, when the highways are in such good condition, these stones have lost their former usefulness, except perhaps, in snowy weather. At the period of their erection their utility would be great, for an obscure track over the dark moors would be easily lost if there was no conspicuous object, a Howe, or a stone, to indicate the right path. In most cases standing stones serve as parochial boundary marks, and they have usually been shaped by man, but sometimes large slabs lying upon the moor have been upended for the same purpose. Other stones indicate the scene of some unfortunate death upon the inhospitable moors in the depth of winter, whilst others may even be pre-historic, and date back to the later Stone Age. But for whatever purpose erected, these stones or " meres " often bear the most singular names. Among the more remarkable are the following :—Tranmire or Old Beckwith Stone, Good Goose Thorn, Nelson Stone, Blue Man in the Moss, Three Lords' Stones, Water Dittins, Harlow Bush, Ticksey Howe, Grey Hall Stone, and so on in great variety. A number possess feminine names, Jenny Bradley on Ingleby Moor, the Margery Stone near Blakey, the Nan Stone on Easington High Moor, and Slavering Ciss on Newton Mulgrave Moor

being instances. It would take us out of our way to discuss the origin and meaning of these cognomens, a task which may be left to the student of place-names. In Fig. 3 a white-marked stone stands on the old earthwork, and with others, indicates the boundary between the parishes of Danby and Westerdale.

Pre-historic stones are not numerous on the moors, or rather they cannot always be identified with certainty, as most of them do not possess any artificial markings which would conclusively establish such an origin. Cup and ring engravings furnish an infallible indication of their ancient British origin, and according to the late Mr. J. R. Mortimer, such carved stones have formerly been portions of slabs derived from ancient Kist-vaens or burial chambers.* The same authority also arrives at the conclusion that the far-famed Killing Pits, near Goathland, are simply due to the quarrying of large stone slabs to make sepulchral chambers and boundary "meres," either in ancient or modern times.

A pre-historic monolith is to be seen on the moors not far from Ugthorpe Mill, but the most remarkable stones known to me occur on Temple Beald Hill on Black Dyke Moor, north of the village of Lealholm. Here, on a slight elevation between two boggy valleys, a quincunx arrangement of ancient menhirs has been converted into a cross-shaped beald or sheep shelter, shown on the annexed diagram. Originally, the site appears to have been occupied by five stones which are from four to five feet high; those at *C*, *D* and in the centre, being thin and flat, and roughly shaped, whilst the two remaining stones at *A* and *B* are more regular and rectangular in form. High stone walls at a later period have been built between the ancient stones; the wall from *A* to *B* is straight, and about thirty-five yards long; and the wall from *C* to *D* decidedly curved and about twenty-two yards in length. This arrangement of the walls gives ample shelter to the moor sheep, and at one time the centre was

* Proceedings of the Yorks. Geol. Soc., Vol. XIII., p. 146.

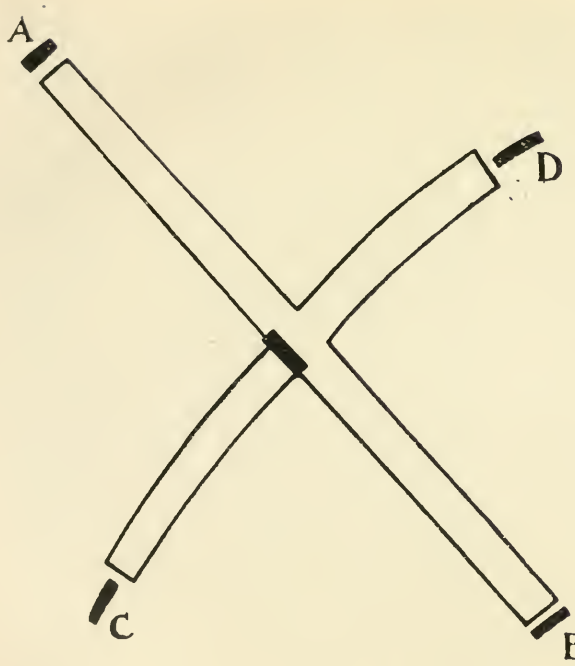


Fig. 4.—Sketch Plan of Temple Beald, Black Dyke Moor.

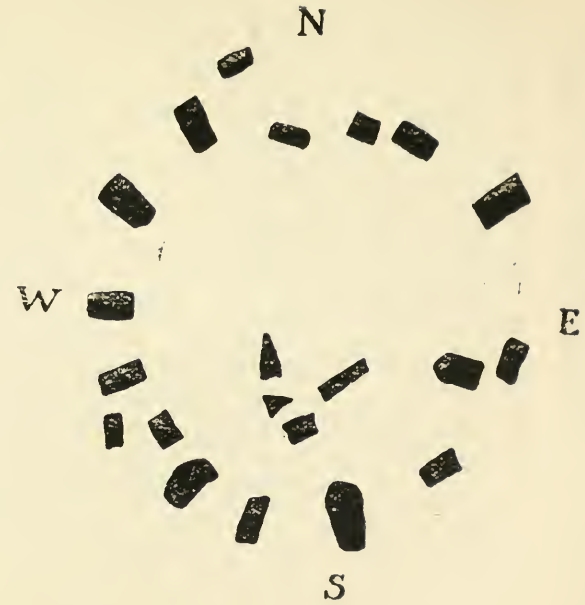


Fig. 4a.—Sketch Plan of Stone Circle, Hardhurst Moor.

partly roofed in—the timbers of an old thatch still lie in an irregular manner across the central angles.

That the five stones are of pre-historic origin is highly probable, seeing that the central one has distinct cup-like markings at the top of the only side visible. The name Temple, too, is suggestive of some ancient circle of stones, for whatever purpose constructed. It may also be remarked that the four stones are not built into the ends of the walls, but stand off a few inches in distinct hollows in the ground.

Temple Beald is the simplest type of stone circle upon the moors, where they are far from common. One of the best-preserved stands on Hardhurst Moor, west of Hayburn Wyke, a plan of which is shown in Fig. 4a.

Intimately associated with both roads and stones are the celebrated crosses of which a considerable number still exist within the confines of the moorlands. Of these, perhaps the best known are Ralph Cross, Lilla Cross (Fig. 70) Mauley Cross, White Cross on Danby Low Moor, another White Cross at Rosedale Head, locally termed " Fat Betty " (Fig. 6), Malo Cross, Percy Cross, and Ana Cross. In many instances the original cross has long ago disappeared, and has been replaced by a more modern erection or by a simple stone. Job Cross on Moorsholm Moor (Fig. 5), is one of the latter, the socketed base being the only remaining portion of the old cross. There are two Ralph Crosses—" Young " Ralph and " Old " Ralph ; the former stands at Rosedale Head, where the road from that valley diverges to Westerdale and Castleton, whilst the latter stands amidst the Heather about two or three hundred yards to the west. Lilla Cross is mentioned as one of the boundaries of Whitby Strand in the charter of Henry I., quoted in the introduction.

It seems likely that many crosses served the same purpose as the stones, and indicated the position of boundaries or acted as landmarks on the pilgrim routes between the great monastic houses of North-Eastern Yorkshire, but it

must be admitted that we possess no very definite knowledge regarding their exact significance.

Though antiquities of the Romans or the Middle Ages are scarce, the same cannot be said of the relics of the Bronze Age. If we follow the line of a moorland ridge projected against the sky, its regular slope will, in many instances, be interrupted by a mound rising from the general level (see photograph of Loose Howe, Fig. 40). This mound may be semi-circular in outline, or it may be flattened on the top, and it indicates the site of a Howe or tumulus of which there are hundreds scattered over the Eastern Moorlands, some being situated on the highest points of the Cleveland Hills. Dating back to the Bronze Age, the Howes, when investigated, have usually been found to contain cinerary urns of crude pottery, enclosing the ashes of some dead chief of the Celtic tribes which formerly inhabited the district. More rarely, weapons of stone and flint occur with the urns, and very occasionally, bronze implements have been discovered.

No apparent order in the position of the tumuli seems to have been followed by those who erected them, for they occur almost everywhere within the confines of Black-a-more, and yet, in their distribution, there are one or two peculiarities which merit attention. Often enough two will be situated on a moorland spur, and then we have a Two Howes Rigg, such as that above the village of Goathland (see map). On Egton High Moor, we have a Three Howes Rigg (Fig. 7), and on Easington High Moor, below Danby Beacon, three Howes of large size bear a similar name, but never do we hear of a Four or Five Howes Rigg. Isolated tumuli are frequent, and usually have some special name of their own, such as Loose Howe (Fig. 40), Flat Howe, Dog Howe, Shunner Howe, and High Woof Howe. Hence, though one Howe Riggs are numerous, no such name figures in the nomenclature of the moors with the exception of One Howe (Ana) Cross on Spaunton Moor.

With regard to the arrangement of some of the crowded tumuli, the late Mr. J. R. Mortimer, the eminent archæologist of Driffield, endeavoured to prove that star-worship prevailed amongst the ancient inhabitants of East Yorkshire, for he thought that many of the barrows or Howes were arranged according to the position of stars in well-known constellations, especially Ursa Major.* On Great Ayton Moor, there are numerous tumuli, mostly of small size, and some appear to be arranged in the form of the Great Bear, but others are grouped indiscriminately. That this arrangement was intentional I think there can be no doubt. Robert Knox, in his "East Yorkshire," was the first to notice it in this district in the following words which are quoted in the paper by Mr. Mortimer. "Near Ugthorpe Rails (seven miles west of Whitby) on that side of the Guisbrough Road, two stone pillars stand erect, having a cluster of conspicuous *houes* between, forming the figure of 'Charles' Wain' (in the constellation Ursa Major)."

Another peculiarity of the Howes is their almost exclusive restriction to the moors, at any rate in North-Eastern Yorkshire. Very few tumuli exist on the low grounds or in the dales, and though they may have been destroyed by cultivation, this hardly seems likely. It cannot be questioned that the Howe builders had a preference for the moors as burial grounds, the highest points being favourite sites. The reason they had for their selection is not at all clear, but it may have arisen from a fear of ghosts—especially those of dreaded chiefs. Probably the ashes of important men only were interred in most of the Howes. The population seems to have been extremely scanty, the number of tumuli being hardly commensurate with a well-inhabited district. These early inhabitants, if animated by an active fear of their dead chiefs, would naturally remove their remains to the wildest and most unfrequented parts of the moors. A thin population of North-Eastern Yorkshire

* Proceedings Yorks. Geol. Soc., Vol. XIII., p. 202, 1896.

Photo by] FIG. 5.—JOB CROSS. *[Frank Elgee.*

Photo by] FIG. 6.—WHITE CROSS, DANBY HEAD. *[Frank Elgee.*

in pre-historic times may also be inferred from the rarity of both stone, flint and bronze implements, as compared with the rich finds of these objects on the Wolds, a fact which goes to prove the wildness and inhospitable character of the moorland region in those far-off times, and which contradicts the theory that the moors then were thickly clothed with trees.

Before we leave the antiquities of the moors, it will be needful to say a few words concerning the so-called British villages—groups of circular pits or hollows which have long attracted attention and which have given rise to endless controversies. The most famous of these pits are the following :—Killing Pits near Goathland, the Danby Low Moor Pits, the Stone Hag Pits on Blakey Moor, the pits near the village of Westerdale, Holey Intake Pits at Glaisdale, the Hell Holes on Hawnby Moor, and the pits at Dry Heads in Harwood Dale, as well as others not so conspicuous.

Ever since antiquaries began to study the remains of pre-historic man in North-Eastern Yorkshire, these pits have been regarded as dwellings, though at what period they were inhabited early investigators do not state, except by vaguely asserting that they are British. If they are pit dwellings at all, they are probably of Neolithic Age. Mr. Clinch ascribes similar pits found elsewhere in the county to that period.*

The first to throw doubt upon the habitation theory was the late Mr. Joseph Bewick of Grosmont, who expressed the opinion that the Holey Intake Pits and the Killing Pits were localities where ironstone had been worked in early times, either by open cast or what is called the " bell-pit " fashion, since these holes occur on the outcrops of seams of ore.† This view was also taken by Messrs. George Barrow and C. Fox-Strangways of the Geological Survey, and by the late Canon Atkinson of Danby. As is

* Victoria " History of Yorkshire," Early Man.
† " Geological Treatise on the District of Cleveland, "1861, pp. 97-100.

well-known, iron was extensively smelted in the dales in past ages, as the innumerable slag heaps abundantly testify, though it must be admitted that the " cinder hills," as they are called, do not occur in the immediate vicinity of the supposed workings.

We have already noticed Mr. Mortimer's opinion with regard to the Killing Pits, viz., that they are old workings for slabs of gritstone, but it is a most remarkable coincidence that the Dry Heads Pits and the Stone Hag Pits should, with the Killing Pits, be found on the same geological horizon, the Grey Limestone Series of the Inferior Oolite, in which occurs an impure band of nodular ironstone. Near Castleton and near Hawnby, there are slag heaps on the outcrop of this seam, whilst on a cinder hill in Westerdale I found a nodule of this ore, which proved conclusively that it was smelted in former times. Are we to suppose that the early inhabitants accidently selected the site of their pit dwellings and that their occurrence on the outcrop of the seam is pure coincidence ? Or are we to think that they carefully selected the sites in Harwood Dale, Wheeldale and Farndale, and that coincidence in these somewhat widely separated localities again led to their being situated on the same geological horizon ? No! The habitation theory is still further weakened if we take the case of the Hell Holes on Hawnby Moor, which also occur on the same stratum. According to the Geological Survey, these holes have been formed in the hard grits by the dissolution of calcareous strata below. But even if this is not their mode of origin, and if they are artificial, we again have the coincidence of outcrop.

But this is not all. The Holey Intake Pits are on the outcrop of another seam of ironstone ; the Westerdale Pits are on the outcrop of the Main Seam of North Cleveland, whilst the Danby Low Moor Pits occur just above the outcrop of another thin band of ore. Here is a piling up of evidence, which, to say the least, is fatal to the pit dwelling

Photo by] FIG. 7.—THREE HOWES, EGTON HIGH MOOR. [*Frank Elgee.*

Photo by] FIG. 8. SALTERSGATE INN. [*Frank Elgee.*

theory. With regard to the Danby Pits, the late Mr. Mortimer was of the opinion that " they seem to have a greater claim to be the remains of pit dwellings than any other group which has come under my observation."* Whilst we must admit that the opinion of such an eminent archæologist, who examined the pits personally, carries great weight, we cannot agree with him on this point. Mr. George Barrow, who geologically surveyed North Cleveland, states that " these holes are more or less full of water, and must have been uninhabitable. Their position is such that water must always be oozing through them."† This is owing to the geological structure of the ground—sandstone overlying shale; water percolates through the sandstone, and is thrown up by the shale, whilst the ironstone occurs between the two beds and crops out on the sides of a hollow near the pits. I have observed similar pits on the same geological horizon near Wood Dale House on Ugthorpe Moor.

Thus, cumulative evidence all points to the pits having been places whence ore was obtained in ancient or mediæval times, and this altogether apart from the absurd theory that the cold bare moorlands were selected as sites for habitations when the great dales would have afforded ample shelter. As a matter of fact, isolated hollows are far from infrequent on the moors; some of these may be due to slabs of stone having been removed; others may be due to the former presence of standing stones which occasionally have a hollow space around their base; whilst yet others may have arisen through geological causes, the dissolution of calcareous strata, etc. It may further be remarked that the pit method is the best that could have been adopted in order to work thin seams of ironstone. Drifts are impossible in layers of ore only a few inches thick, but by digging down a few feet in suitable situations, the ore can easily be ex-

* Proceedings Yorks. Geol. Soc., Vol. XIII., p. 406, "So-called British Habitations on Danby Low Moor."

† "Geology of North Cleveland," p. 59.

tracted, and in some cases might even be worked out round the bottom in bell-pit fashion, though this has still to be proved.

The names associated with the moors are well worthy of attention, and quite apart from their historical and philological value, they possess a novelty that will appeal to many readers—even to those in whom they arouse no corresponding images of the scenes they designate A stranger examining a map of the moorland region cannot but be impressed with the singularity of its nomenclature. What is he to think, for instance, of such names as Great Hograh, Cockan Ridge, Obtrusch Rook, and Coldman Hargos, or such names as we have mentioned in connection with the stones? In most cases the place-names cannot be understood until laborious researches have been made in old documents, local dialects and philological works. We should digress too much if we dealt in detail with them, but a few remarks concerning some of the more interesting will not be out of place.

Many are of Scandinavian origin, and more or less describe the character of the particular moors to which they refer. Such is Murk Mire Moor near Egton, the name of which has been derived from the Old Norse, *myrkr*, signifying dark, and *myrr*, a moor or boggy place; in which sense "mire" is perpetually employed in North-Eastern Yorkshire. Again, the word "swang" is of frequent occurrence—Glaisdale Swangs and Moss Swang (Fig. 28)—a word originating in the old Norse *svangr*, a hollow usually more or less boggy. Then we have "syke," another term for swampy localities; "rook" or "ruck," piles of stones or turves; "slacks," shallow valleys; "haggs," wild and broken ground; "skews," small twisted valleys such as Hole Skew near Freeborough Hill (Fig. 57). All these are probably derived from the names bestowed by descendants of the Scandinavian settlers of the eighth or ninth centuries. Other names not necessarily of similar origin are also indicative of the nature

of the moors, and of these it needs but to mention Stony Moor, near Newton-on-Rawcliffe, a piece of land literally covered with sandstone boulders.

A particularly instructive name in frequent use is "Grain," usually applied to small streams rising in high moorland. Thus we have Grain Beck, the easterly branch of Baysdale (Fig. 53); another Grain Beck occurs on Allerston High Moor, and where it rises in May Moss in two converging streams, one of these is termed Long Grain and the other Little Grain. Then we have high Mossy Grain and Low Mossy Grain, the names of two farms on the moor between Scarth Nick and the Chequers Inn, though they are erroneously called "grange" on most maps. Now the word Grain, as thus employed, has obviously nothing whatever to do with corn, but we have a clue to its application in the local dialect in which a "grain," as defined by Canon Atkinson, means "a separate, linear portion of a thing, whether still attached to or detached from the rest; as the branch of a tree, the tine of a fork,"—and again the word "graining" signifies the fork or division of a tree into branches. He derives these words from the Old Norse *greina*, to divide, or the Swedish dialect word *gren*, the angle which two branches of a tree make with one another, also the angle made by the thighs.* Such being the meaning and origin of the word, its application to streams is obvious, for it will almost invariably be found that Grain is used where the head waters of a stream divide and shoot into the moorlands. Grain beck is one of the two branches of Baysdale Beck, the other being Black Beck; similarly with the Grains at May Moss. The application is clear in the case of Helwarth Beck, where it divides near its source at Pye Rigg on Staintondale Moor, for the intervening ridge is termed Helwath Grains. The account of the origin of this word may be taken as typical of the manner in which the

* "Cleveland Dialect," p. 222.

investigation of moorland place-names should be carried out. Their origin cannot be discovered by guessing.

Other names are indicative of the former animal life of the district. Wolf Pit Slack on Danby Ridge and Hart Leap Gap on Glaisdale Ridge speak for themselves, whilst Swinsow Dale near Freeborough Hill was probably the haunt of the Wild Boar. Arnsgill on Snilesworth Moor points to the haunts of the Ern or Eagle, and that the Raven was once numerous is shown by such place names as Raven Scar on Hasty Bank, Raven Gill, and Raven Stones on Wheeldale Moor.

Howe, too, is an abundant place name, but has often suffered contraction as Biller Howe into Billery, Silp Howe into Silpho, Brock or Brox Howe into Broxa, and Blake Howe into Blakey. The coal-mining operations, which used to be carried out so extensively on the moors until even quite recent times, have also given a few names to moorland scenes, Collier Gill, Coal Ridge, Collier Lane, etc.

Many moors take their name from some village or dale in their vicinity, though Pickering Moor lying to the south of Goathland and west of Newton Dale is several miles from that old rural town. Some names are repeated, *e.g.*, there is Spaunton Moor north of Hutton-le-Hole and Spaunton villages, and another in the Vale of Pickering to the south of these places. When repeated, a moor name is usually conjoined with the terms "high" or "low." In the Esk Valley, at Danby, the moor on the North Cleveland watershed is called Danby Low Moor, whilst that to the south on Danby Rigg is called Danby High Moor. Altitude has determined this appellation as the North Cleveland moors are generally lower than the southern. In the south of Black-a-more, the Low and High Moors, though determined by elevation, are somewhat differently situated with regard to the places whence they obtain their names. Allerston Low Moor lies to the north of the village of Allerston ; further north still, on more elevated land, is Allerston

High Moor. Again, the like nomenclature prevails with the moors of North Cleveland, for south of Roxby we find Roxby Low Moor, and nearer the watershed on higher ground, the corresponding High Moor which runs into the afore-mentioned Danby Low Moor.

The word "moor" itself throws light upon the nature of the land at the time when it was applied. In old documents the word "Forest" means not only country covered with trees, but heathy land as well, and the district with which we are dealing furnishes two instructive examples of this use of the word, viz. :—the Forests of Pickering and Danby. But so far as I am aware, "moor" was never used in a double sense, for the word appears always to have indicated what it does to-day—heather-clad land.

According to Canon Atkinson, moor has another and more special meaning. It is used for the Ling or Heather itself, particularly when in flower. At the close of the eighteenth century, there was a third use of the word, the application of which will be seen by quoting a few lines from that somewhat remarkable and little-known work, Marshall's "Rural Economy of Yorkshire," published in 1796. Speaking of the Eastern Moorlands, he says: "The soil is invariably a Black Moor. The moor of fens appears obviously enough to be composed of the decayed roots and other parts of vegetables, with a greater or less proportion of sand and mud," whence it may be inferred that "moor" was used as a term for a particular kind of soil, in which sense Dr. Young, in his "History of Whitby," also employs the word.

The word is in all essentials identical with the old Norse *mor*, signifying peat, turf, heath or Ling, and if we look at its meaning in the Gothic languages we shall find that it is everywhere the same, though with some elasticity in its application. In Suio-Gothic, *mor* is a marshy place, also the undergrowth in a wood; Danish and Swedish *mor*, a tract of fenny land; Danish dialect, *moor* or *mor*, land

where turves may be cut; Anglo-Saxon *mor*, waste land, a moor, heath; Dutch, *moer*, and German, *moor*. In the last instance, however, the word is usually applied to marshy or swampy land, and not necessarily to land covered with Heather for which the word "Heide" is generally used.

These meanings are instructive, for it is important to note that, with one exception, the word moor is never applied to land covered with trees, and the exception refers to the undergrowth, and not to the wood itself. Hence we must conclude that when our Scandinavian ancestors began to settle in the moorland districts, the moors then, as now, were practically treeless. That the heather-clad uplands of North Yorkshire should not be called Heaths is another significant fact. In the south of England, the worth Heath is everywhere to be met with, but it occurs only once in the district we are considering, and in this instance it is applied to a farm near Staintondale—Providence Heath. Why the word should not have been used we are not in a position to say. When we bear in mind the meaning of the German words Heide and Moor, the latter referring as a rule to boggy land, it is possible that moor has been applied in North-Eastern Yorkshire on account of the generally wet character of the uplands, which are in marked contrast to the dry sandy heaths of southern England and other parts of the country. On the other hand, the two words may be indicative of racial differences in the Teutonic colonists of England—the word Moor being, as was said above, essentially Scandinavian, whereas Heath may be indicative of Germanic influence.

The name "Black-a-more," which we have selected for the title of the present chapter, is not strictly applicable to the whole of the Eastern Moorlands. It formerly designated that part of the district not included in Cleveland, viz., the country south of Whitby, the central watershed and the Cleveland Hills. But the name is so convenient,

Photo by] FIG. 9.—TURF STACKS, CASTLETON RIDGE. *[Frank Elgee.*

Photo by] FIG. 10.—CROWBERRY (*Empetrum nigrum*). *[Frank Elgee*

and so eminently descriptive, that we have not hesitated to employ it in these pages as a term for the whole of the moorlands of North-Eastern Yorkshire, though it is now obsolete even in a restricted sense. It dates back to early times; the first historical mention of it occurs in the Chronicle of John of Hexham (Henry II., 1154-1189), who states that Rievaulx Abbey was situated " in solitudine BLACKOU MOR." Leland, Camden and Drayton are other old writers who use the name.

The absence of villages and the rarity of houses is a negative feature which the moors possess, for only here and there do we come across a building and then it is usually associated with small enclosures or other special circumstances. The moorland inns are noteworthy; we have the " Falcon " on Harwood Dale Moor, " Saltersgate " on the Sleights and Pickering high road (Fig. 8), " Stape " Inn on Pickering Moor, and the " Chequers " on Osmotherley Moor. We may conclude from the lack of moorland villages—and by these we do not mean such places as Goathland, Lastingham or Castleton, which only touch the edges of the heather-clad land—that at the time when settlements were being formed in North-Eastern Yorkshire, the heaths were wild and open as they now are, and that if a settlement was anywhere possible it was in the dales. If the moors had then been forest land, it is difficult to understand why villages or hamlets should not have been built upon them since the trees would have afforded ample shelter.

There yet remain two aspects which we must consider before bringing this chapter to a close. We refer to the burning of the moor, and the cutting of turves, both of which exercise no small influence upon the vegetation and constitute a disturbing factor in the plant life of the uplands. The burning of the moor is known as " swiddening " or " swivvening," and to the areas burnt the name " swidden " is applied. Usually the Ling is fired during the months of March and April, in order to promote a young growth of

Heather for the Grouse. The burning is not done indiscriminately but spaces that have become overgrown with tall Heather are first marked out, and then carefully ignited. In the early spring small fires may be observed sending their columns of smoke high above the moorland ridges. Occasionally fires occur, intentionally or accidentally, upon a larger scale, and they present quite a grand spectacle, the flames roar over the tops of the plants, and vast clouds of smoke ascend into the air. Such a fire broke out on Easter Sunday, 1909, on the hill of Kempswithen near Castleton, and only after some hours of strenuous exertion on the part of the keepers was it finally extinguished, leaving in its track a black cindery waste, which will be some time before it is re-clothed with vegetation. Another large fire on the Guisbrough Moors in March 1904, could be seen at night from the sea-shore near Redcar, several miles distant.

Deep peat is sometimes known to catch fire and smoulder for weeks, and in order to check its progress trenches have to be dug, and the fire is allowed to burn out. Fires of this nature have happened on the peaty moors at the heads of Glaisdale and Iburndale.

Hardly any part of the moors has escaped burning, and everywhere amongst the vegetation we meet with the burnt Ling stems or "gouldens" as they are termed. In Figs. 40 and 49, the grey "gouldens," so characteristic of old swiddens, are well shown in the foreground. The importance of regularly and carefully burning moors in order to ensure the health of Grouse has long been recognised, but the reasons for this have only recently been made manifest by the expert researches of the Committee of Inquiry on Grouse Disease.* It appears that Grouse disease is due to thread-worms (*Trichostrongylus pergracilis*) which are taken along with the Heather shoots into the digestive system of the birds, and in their intestines the worms pair, and lay eggs that pass out with the droppings. When a moor

* "The Grouse in Health and Disease," 1911.

gets overstocked, the Heather becomes infected with these thread-worms, and the disease spreads rapidly. The Committee also established the fact that rain and damp are active causes in promoting the disease, and that by well-burning the moors, by avoiding overstocking, and by good drainage, much may be done to stamp out epidemics.

Burning the Ling is also a preliminary step in turf graving which takes place all over the drier moors, usually between hay time and harvest. A familiar moorland scene is the pointed turf stack or " ruck " (Fig. 9), for after the turves or " flaughts " have been cut they are stacked to dry, and are then used as fuel, for building walls, Grouse shooting stands, etc. Those who are unacquainted with moorland life frequently confuse " flaughts " with " peats," two entirely different products. The " flaught " is essentially a moorland sod containing much soil and humus, together with the roots of Ling and other plants. It is always taken off a swidden by means of a triangular spit or spade with one edge turned up at right angles, and with a very long shaft. This tool is forced into the soil and the thickly entwined Heather roots by a peculiar action of the hands and thighs, the latter being protected by pieces of wood called " knappers." On the other hand, a " peat " obtained from a peat-hole, excavated in some moorland Moss or slack, is usually more or less brick-shaped, and consists principally of Bog-moss. It makes a much better fuel than the flaught, and for this purpose it is alone used.

We have now made ourselves acquainted with many features of Black-a-more ; its roads, earthworks, stones, crosses, howes, and names. From the course of the roads, the position of entrenchments, the absence of moorland villages, and the word moor itself, we have concluded that from early times, perhaps two or three thousand years ago, the high moors were never clothed with trees. The significance of this conclusion has wider bearings which will become clear in the course of our investigations into the

botanical history of the moors, but its importance for the moment lies in the fact that we have deduced it from those aspects of the uplands which at first sight would be thought to throw no light on such a problem. And yet it will be manifest that all human works of whatever age on the moors must bear witness to the conditions which existed at the time of their erection.

CHAPTER II

THE FAT MOORS

CONSPICUOUS as are those aspects we have just described, they are nevertheless not so conspicuous as the Heather, which is such a distinctive characteristic of the moors that we propose to begin our investigation into their origin by a consideration of their plant life. Even to those who have not made botanical geography a special study, it must be obvious that moors constitute a natural plant community or " formation," as the German botanists call it, comparable with other great natural assemblages of plants—forests, steppes, tundras, dunes, prairies, swards, savannas and swamps. Now although Heather is the most dominant plant of moorlands, it is but one of a large number of species which flourish together under similar conditions of life. The term moor, therefore, includes numerous minor plant groups or associations characterised by the dominance of a particular species. Thus, using moor in a generic sense, we find that it can be divided into distinct species or kinds :—Heather Moors, Cotton Sedge Moors, and Grass Moors, and these in their turn can be further sub-divided according as the constituents of their vegetation vary. It is important to have a clear understanding of what is meant by plant associations, and in our account of the vegetation of the Eastern Moorlands this great botanical conception will be clearly exemplified. The circumstance, too, that moors are a natural plant community more or less untampered with, renders them of altogether exceptional interest in a land where almost everything natural has been " improved " away.

We shall first deal with moors upon which Heather is

most abundant, taking them as typical of moors in general and at the same time we shall examine the conditions of soil and climate which lead to their development. This survey will enable us in the succeeding chapters to note variations from the typical moors and their causes, and to trace the botanical changes that have taken place upon them.

The botanist with his plant associations has but extended that common knowledge of plant groups detected by our observant forefathers, who, more so than ourselves, were in daily contact with nature, and to whom a discrimination of the elements of their primitive environment was a necessity. To the untrained eye of the townsman, all heather-clad land appears alike. But that experience of the moors handed down from the earliest settlement of North-Eastern Yorkshire has become engrained in the residents of the dales, and they perceive differences on these wastes which are of primary importance in their natural history The terms employed by the dalesmen in their knowledge of the moors present in rough outline the beginnings of a more scientific and exact analysis of the ericetal vegetation. Fat and Thin moors, Mosses and Swangs are words expressive of the different kinds of moorland, and in selecting these terms for the titles of our chapters, the intention has been to convey a conception of the manner in which the heather-clad uplands of Black-a-more are regarded by men who have spent their lives upon them.

When we turn to the local designations of the different kinds of moors, we find that botanical distinctions are not so much in mind as the nature of the soil, and a local term may cover a variety of plant communities which in a scientific classification would be separated. Thus the term fat moor embraces several distinct types of vegetation flourishing upon a soil which consists of blackish brown peat from one to four feet in thickness, and more or less damp even in the driest weather. The peat or raw humus is rich and

" fat " as contrasted with the thinner deposits of the same substance on other moors, and in traversing a Heather moor of this nature, one's feet sink perceptibly into the soft peat, which can be kicked away from the surface.

The vegetation of many fat moors consists almost exclusively of Heather or Ling (*Calluna vulgaris*)—the Callunetum of the botanist—and in these instances, other ericetal plants rarely become dominant, or may even be totally absent. On Kempswithen, a ridge of high land (960 feet above sea level) lying between Kildale and Baysdale, we have a splendid example. Here, the level surface of the ridge is covered with rank Heather from two to three feet in height, growing upon raw-humus nearly a foot deep. Other plants are scarce. Occasionally the Pink Bell Heath (*Erica tetralix*) and the Bilberry or Blaeberry (*Vaccinium myrtillus*) may be seen, and a tuft or two of Cotton Grass (*Eriophorum vaginatum*) in damper places, but the Ling flourishes so vigorously that it has practically driven out everything else.

Another peculiarity of the fat moor can be observed on the same ridge. Between the masses of Heather are bare spaces showing brown peat of such thickness as to hide nearly all traces of the underlying rock. This rock is the Moor Grit or White Flint, a hard compact sandstone which on thinner moors often dots the surface with glossy white boulders and stones. But on Kempswithen, these are all enveloped in the thick peat, and only here and there a " Crow-stone," as they are sometimes called, is to be seen. On the bare black spaces water collects and flows, and white sand spreads in curious patterns over the surface. When these moor pools evaporate, a peaty film is left, beneath which numerous beetles, spiders, and centipedes take refuge.

Flowerless plants, especially Lichens, flourish under the Ling. Among them is sure to be found the Reindeer Moss (*Cladinia sylvatica*), a plant that forms extensive carpets

on the peaty soil, and which frequently has other species of the same genus growing with it.

In northern latitudes this Lichen attains a much larger growth than here, and is one of the principal foods of the Reindeer, an animal that formerly lived upon our moors, as some antlers found in a peat bed near Kildale prove. This unmistakable plant possesses pale greyish-green branched tufts and stems, and attains its most luxuriant development in wet and wintry weather. Lichens—those strange symbiotic communities of Algæ and Fungi—play a prominent part in the life of moors, and, so far as Cleveland is concerned, were specially investigated many years ago by the late William Mudd, of Great Ayton.

Reverting to the covering of boulders by peat: on fat moors, where large blocks of sandstone occur, the black soil is often banked up against the sides of the stones, and Bilberries and Crowberries (*Empetrum nigrum*) will then grow upon it. On Saltersgate Moor, a group of rocks called the "Grey Stones," is difficult to find now, as they have become more or less embedded in peat.

Towards the central watershed, the fat Heather moors are somewhat different, although there is the same brown peat, the same absence of boulders, and the same dominance of the Ling, which possesses a luxuriant growth. At the head of Stockdale, one of the branches of Westerdale, and at an elevation of over one thousand feet, we find this moor variegated by the presence of the Bilberry, a plant occurring everywhere on the uplands but not specially characteristic or dominant except on slopes, and on the moor in question, it only becomes abundant on slightly rising ground. In May and June its bright green leaves lend a brilliant colour to the dark moor, whilst in autumn as the purple Heather fades, the foliage of the Bilberry glows with a scarlet light. Ling and Bilberry are undoubtedly the principal plants of the higher fat moors, just below and encircling the Mosses of the central watershed.

The Fat Moors

The peat of the Stockdale Head fat moor is much thicker than that on Kempswithen, and the surface of the ground is eroded into channels and gullies on account of the heavier rainfall to which the high moors are subjected. The wetness of the moor favours the growth of Cotton Grass (*Eriophorum vaginatum*) which is interspersed amongst the Heather in " hussocks," as the men of the moors say. Where the Heather has been burnt, the Cotton Grass afterwards becomes the sole occupant of the swiddens with the exception of occasional patches of lichen. Such conditions present an aspect far from cheerful, and in gloomy weather a more dreary scene will not be found.

In North Cleveland, especially on the slopes leading up to Danby Beacon by Bella Dale Slack—Easington High Moor—we meet with another kind of wet fat moor, perhaps even wetter than the one at Stockdale Head. The slope is covered with peat nearly four feet thick, and the Ling is very strongly grown, whilst beneath it are large green, red, and yellow cushions of Bog Moss (*Sphagnum*). Plant sponges best describes these bosses of Sphagnum, for not only do they readily absorb rain which falls upon them but they also possess the power to take up moisture from the atmosphere, and to retain it in their tissues for a long period, even in dry weather. There can be no doubt that Bog Moss is the most important plant on the moors after the Heather, and we might almost say there would be no moors without Sphagnum at one time or other entering into their composition.

Besides Sphagnum, the Flying Bent Grass (*Molinia varia*) is a conspicuous element in the vegetation. A grass more or less peculiar to some wet moorlands, it can easily be recognised, for when the plant decays, its leaves become detached from the rootstock, and twist up like a corkscrew. In this condition they can easily be pulled up by the hand, and if growing in an exposed situation, are liable to be swept away by the wind. On this last named moor Cotton

Grass "hussocks" are abundant with isolated clumps of Rushes or "Seaves" (*Juncus communis*). When seen in August, such a moor is more variegated than the pure Heather moor. The purple Ling is broken by the white plumes of the Cotton Sedges, the blue-purple panicles of the tall Flying Bents, the dark green culms of the Rushes, and the lighter hues of the Bog Mosses.

Easington High Moor presents another feature which must not be passed over without comment—a feature indicative of transitional states to the wettest moors or Mosses. Here and there are spaces without Ling, supporting in one place nothing but Cotton Sedges, in another true Sedges (*Carex* species), and yet again little bogs filled with Sphagnum. Such plant groups flourish on the site of bare peaty areas that have become water-logged, and will in most instances be replaced by Heather.

Why is this particular moor so wet? The rainfall on the North Cleveland watershed is certainly much less than on the central watershed, say at Stockdale Head, for the difference in elevation amounts to at least three hundred feet. The case is not without interest, for it shows that a wet moor may arise where there is a lower rainfall providing the rocks on which it rests are non-porous. And this is exactly what we find on Easington High Moor. The strata beneath the peat are clayey shales intercalated with thin layers of sandstone. Water cannot percolate through this shale, and either accumulates on the surface, or flows down the slopes. There are some very extensive tracts of moorland upon these shaley rocks that give origin to the wettest of fat moors. The enormous area of moorland lying east of the Murk Esk Valley—Sleights, Sneaton High, Widow Howe, and Fylingdales Moors—covers these shales, and as a consequence is wet and barren in the extreme. Not far from Goathland, near Eller Beck, a wet moor of this type has great tufts of Flying Bent and the Pink Bell Heath mixed with the Ling. Round Lilla Cross peaty Heather moors

prevail, and where these have been burnt, there is a tendency for the Pink Bell Heath, a species partial to damp places, to spread on to the swiddens.

The moors on the Tabular Hills are usually somewhat thin, but on the summit of the great hill of Black Hambleton, 1300 feet above sea level (Fig. 46), there is a rather peculiar fat moor resembling in many of its aspects that at Stockdale Head. In addition to a thick peaty soil with Ling and Bilberry, this moor has a quantity of Crowberry (*Empetrum nigrum*) in its vegetation with here and there small patches of Cotton Grass. The Crowberry is by no means scarce on the Eastern Moorlands, but rarely becomes a dominant feature of the plant life. Usually it occurs sporadically in large clumps, often spreading over stones and rocks, but on Black Hambleton makes quite a conspicuous show with its deep green cylindrical leaves and reddish trailing stems. On Eston Moor, the most northerly outlier of the heath vegetation in East Yorkshire, the Crowberry flourishes in bosses or clumps, several feet in diameter, under Birch trees.

An interesting and anomalous growth of this plant was observed in Baysdale, not far from Hob Hole. Along the stream-side runs a stone wall against one face of which the downwash from the slopes above has accumulated so thickly as to be almost level with the wall top. In this downwash are numerous plants,and a Crowberry has sprouted over the wall and grown downwards in the form of a large hanging bush. At first sight the plant appears to be growing upwards, for its lower end just touches the herbage. The stem where it passes over the wall is nearly as thick as a man's wrist! (Fig. 10).

Returning once more to the fat moors, we must notice another type before proceeding to discuss their life-conditons and origin. It occurs at the southern end of Black-a-more, on Cropton Moor, at the foot of the Tabular escarpment. Here on wet peaty ground, Heather and the

Flying Bent are almost equally abundant, whilst associated species are the Pink Bell Heath, and the Sweet Gale (*Myrica gale*). Again, just west of and below the Cawthorn Camps, the moor of Peat Rigg on a spur of the escarpment presents similar characteristics. Ling is the principal plant, with an abundance of Flying Bent, Pink Bell Heath, Sweet Gale and Rushes.

In this association we are introduced to another moorland plant, the Sweet Gale (*Myrica gale*), a species of much interest, and with which we shall deal more fully when treating of the slacks. It is a catkin-bearing shrub, with sweet aromatic leaves whose perfume pervades the air on warm summer days. Gale often attains a height of four or five feet, is partial to wet moorlands, and in winter can be recognised at some distance by its tall purplish stems projecting above the Heather.

After a fat moor is burnt it frequently happens that until the Ling attains a vigorous new growth, the vegetation appearing on the swiddens is quite different from the dominant plants of the surrounding moor. What this vegetation will be depends upon a number of factors—the character of the environing plant associations, the nature of the soil, the effect of the burning, and the position of the swidden in regard to slope and drainage. Mr. R. B. Turton, of Kildale Hall, informs me that the nature of the fire has also to be considered. Where the fire passes over the Heather with the wind behind it, the plant comes again much earlier than when the burning has been a longer process. In the former case the fire has not affected the underground parts of the plants to any large extent, and consequently they re-appear more quickly; whereas in the other case, the whole of the Ling may be destroyed, and can only be renewed from seeds.

In examining a swidden, it is important to bear in mind that age undoubtedly changes its plant association, and, although a succession is traceable, yet this varies consider-

ably. As a rule, ten to fourteen years elapse before a swidden becomes reclothed with tall Heather, and during this time other species of quicker growth obtain a temporary occupation of the ground, but the Heather ultimately ousts all competitors.

On some swiddens Heather clothes the ground before any other species, but the first plants to appear on a well-burnt swidden are usually flowerless—Liverworts, Mosses and Lichens. The principal Liverwort found under such conditions is *Lophozia inflata*, and it invariably assumes a blackish colour, and occurs in thin flat patches, but near water it is usually vivid green. If the moor be at all damp, the only Bog Moss seen on the swiddens is *Sphagnum papillosum* var. *confertum*, a moss that shortens and crowds its branches when growing in drier situations.* *Webera nutans*, a true moss, is often extremely abundant, whilst at a later period the Hair Moss (*Polytrichum commune*) and *Ceratodon purpureus* are not infrequent. Some swiddens on Great Ayton Moor have been almost covered with Lichens chiefly of the genus *Cladonia* (to which the Reindeer Moss belongs), *C. sylvatica, ulcicornis, pityrea, cornuta, lepidota*, etc. Dr. Graebner in his account of the origin of the North German moors, mentions a stage in their development in which *Cladonia* forms the principal element of the vegetation.† Undoubtedly the plant life of swiddens gives us a clue to the floras that follow one another on a bare sandy soil that is passing into Heather moor, but as these burnt areas already possess the indispensable peat, their succession of vegetation cannot be entirely relied upon to furnish us with a correct conception of the plant associations that occupy a sandy surface before it becomes moor.

At later stages the flowerless components of the vegetation of swiddens have more or less to yield to the flowering plants and a very mixed flora sometimes results. Often

* Ingham, "Naturalist," July 1911.

† Dr. P. Graebner, "Die Heide Nord Deutschlands," pp. 82-91.

a turf develops, consisting of Heather, Bilberry, Crowberry, Tormentil (*Potentilla tormentilla*), Heath Rush (*Juncus squarrosus*), Brown Bent (*Agrostis canina*), and Hair Moss (*Polytrichum commune*), whilst occasionally grassy swards composed of the Brown Bent (*Agrostis canina*), Early Hair Grass (*Aira præcox*), and Sheep's Fescue Grass (*Festuca ovina*) overspread the burnt spaces. In some instances, two or three, or even only one species, occupy the ground for a time. On Redman Plain, a moor due north of Lastingham, Ling is the chief plant, and on the old swiddens there are extensive spreads of the Purple Bell Heath (*Erica cinerea*) forming what may almost be termed a " cinerea " moor. In places this plant yields to a strong mixture of Heather and the Pink Bell Heath (*Erica tetralix*), whilst on more recently burnt areas Heather dominates towards the edges, with young growths of both Heaths in the centre. On fat moors, such as that at Stockdale Head, the swiddens are often covered with beautiful growths of Bilberry. On Glaisdale Rigg this was very noticeable, and on one swidden Bracken was observed, a plant that rarely flourishes on a fat moor.

The uniformity of the moors is much disturbed by burning, and there can be little doubt that if left alone, rank Ling would be even more dominant than it is at present. By swiddening, many important constituents of the ericetal flora, the Heaths for instance, become much more abundant, and so help to break the monotony of the extensive stretches of Heather.

Under the term " fat moor," we have described four distinct plant associations, viz. :—

Pure Heather Moor.
Heather and Bilberry Moor.
Heather, Flying Bent, Cotton Grass, and Common Rush Moor.
Heather, Flying Bent, Common Rush, and Sweet Gale Moor.

The two first are more wide-spread than the others, and

together with Heather moors of the thin type, cover the greater part of the moorland area. All flourish on moderately deep peat, and their facies vary owing to the presence of

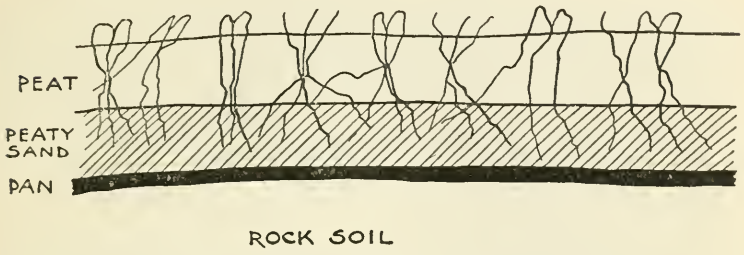


FIG. 11.—DIAGRAM ILLUSTRATING THE FORMATION OF MOORLAND SOIL.

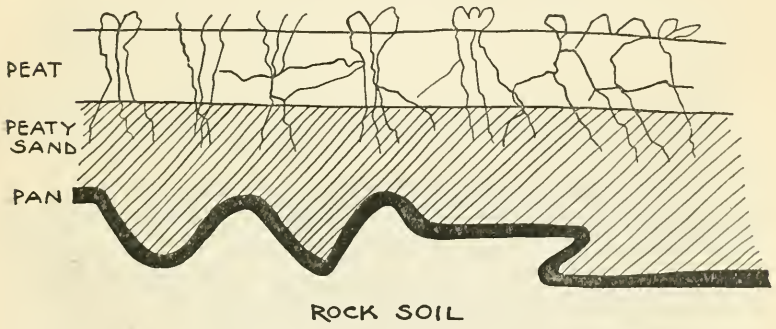


FIG. 12.—SECTION IN MOORLAND SOIL, SHOWING CONTORTED PAN, BRANSDALE.

a greater or less quantity of water. Our next step must be to examine more closely the conditions of life under which they exist.

Generally speaking, plants are adapted to two main conditions of life: the soil from which they obtain their mineral food and water, and the atmosphere from which they obtain their carbon under the influence of sunshine. As these conditions are ever varying in different parts of the earth, their interaction is reflected as it were, in the infinite variety of form assumed by those organs of plants in direct contact with the soil and the atmosphere—the roots and the leaves. Consequently, when we have ascertained the chemical and physical characters of the soil on which any given plant association maintains itself, and the climatic states—rainfall, wind, temperature, sunshine—to which it is exposed; and further, when we have also ascertained the contrivances by means of which the various species constituting the association flourish under such conditions, we shall then know why that association exists in that particular locality.

Already we have seen that peat is essential to the development of the fat moor, but if we examine the soil more closely, we shall find that it possesses other peculiarities which cause it to exert more complicated effects upon the vegetation. At Stockdale Head where the fat moor slopes up to Stony Ridge, there is a gully cutting down into the sandstone rock of the upland, and in rainy weather it is the scene of violent torrents of water. The sides of this little ravine show in the clearest manner the various deposits which comprise the soil formation of many moors (see diagrams in Figs. 11 and 12).

First, we have the surface peat succeeded by a bed of bluish grey sand, usually about ten inches thick, stained with peat, and penetrated by plant rootlets. At the base of the sand is a thin band, from a quarter of an inch to an inch in thickness, of a hard brown substance cementing together small stones and grains of sand, and cutting off the plant roots from the soil upon which it rests.

This thin band is one of the most important phenomena

Photo by] FIG. 13.—ANCIENT EARTHWORKS NEAR CAWTHORN CLOTHED WITH PURPLE BELL HEATH (*Erica cinerea*). [*Frank Elgee.*

Photo by] FIG. 14.—HARWOOD DALE PEAT HOLES. [*Frank Elgee.*

of the moors. Known as moor-pan, it extends as a hard layer, more or less horizontal, but not always visible in sections, because it is so readily destroyed by rain and frost. Sometimes it is contorted as shown in Fig. 12, which represents a section in a roadside quarry on Rudland Rigg overlooking Bransdale. Here the pan is at least two inches thick, a greater development than has been observed anywhere else in the district. That pan exists under all the fat moors cannot be proved; and, although it has been detected in many localities, there is no evidence that it extends continuously for miles, as is the case on the North German moors.

A band of small stones and pebbles often takes its place, and occasionally these have their upper surfaces thinly coated with a deposit of pan. In fact a series of sections can be compared in which, other things equal, we may trace the gradual development of the pan from the thin layer just mentioned, to deposits such as that on Rudland Rigg.

Where roads have been banked up on either side, sections reveal little of value; but, on the contrary, where a track has sunk deep into undisturbed soil, interesting features may be noticed. The humus, perhaps not more than six inches thick, overhangs the face of the exposure as a projecting ledge, well seen in Fig. 42. By feeling with the hand at the junction of the peat and soil, hard cakes of pan can often be found. The projecting ledges are caused by the erosion of the sand proceeding more rapidly than that of the humus above it, for the latter is bound together by the roots of plants and consequently offers a greater resistance to denudation. In rainy weather, water, more or less stained with peaty acids, runs down the face of these sections, and flows into the gutters by the roadside, where beautiful growths of Bog Moss, usually *Sphagnum acutifolium*, flourish.

The general chemical composition of moor-pan can be seen from the following analysis for which I am indebted to Mr. H. Frankland, F.I.C., F.C.S., of Middlesbrough :—

Analysis of Moor Pan from Rudland Rigg.

Oxides of Iron	45·14 per cent.
Oxides of Manganese	0·19 ,,
Alumina, etc.	7·85 ,,
Lime	1·30 ,,
Magnesia	0·90 ,,
Silica	21·60 ,,
Sulphuric Acid	0·37 ,,
Phosphoric Acid	0·15 ,,
Organic matter combined with water etc.	22·50 ,,
Total	100·00 ,,

The quantity of iron amounted in this sample to 31·60 per cent., and practically the whole of it existed in the form of peroxide.

The existence of moor-pan prevents the roots of the heath plants from penetrating the rock soil below, restricts them to the peat and peaty sand, and furthermore, dwarfs the growth of any seedling trees that may chance to spring up amidst the Heather. Young trees, chiefly Mountain Ash or Birch, more rarely Oak and Scots Pine, may frequently be observed on the moors, but they seldom rear their stems above the level of the surrounding vegetation, though here and there, an isolated Pine, Mountain Ash, or Birch, will attain a maturer growth, and stand like a solitary sentinel above the level of the flat moorlands. As a rule, the roots of the seedlings cannot pierce the pan, and consequently being unable to reach the comparatively richer soil, the plants obtain what sustenance they can from the impoverished superficial layers; but this is not the sole cause at work in preventing the growth of large trees, for amongst others must be named the powerful winds which sweep over these wide spaces, and the Moor Sheep which continually browse upon the seedlings.

Such, then, are some of the features presented by the moorland soils which are more complex than we might

have at first supposed. It is obvious that two of the deposits—peat and pan—must be of secondary origin, for the surface of the moors must, at a former period, have consisted solely of the soil produced by the weathering of the strata. Peat or raw-humus is essentially a product formed by plants when they die and decay; and it is clear that until a rock-soil has become clothed with vegetation, no such deposit can arise. We must, therefore, trace the origin of these secondary formations since it is to the present soil conditions that the heath plants are especially adjusted, conditions so peculiar that species belonging to other plant associations cannot flourish under them.

One of the first facts which strikes the observer is that the rock-soil of the Eastern Moorlands consists more or less of sand and sandy clays. In other parts of the country the association of heaths with similar sandy soils has also been observed. Thus the East Anglian heaths occur on flat sandy country in Norfolk and Suffolk; those of the south-eastern counties occur on similar soils; and so with the heaths of Hampshire and the Midlands.* On the Eastern Moorlands, the rock soils have been derived from great beds of sandstone, grit, and sandy shale, whose principal characteristic is that they consist chiefly of quartz grains cemented together by iron oxides, and in some instances—the Moor Grit is one—by silica. These rocks will be described later in Chapter X., and photographs of typical sections are shown in Figs. 41 and 42. Now it is a peculiarity of such rock-soils that they are poor in plant food, in those soluble mineral ingredients absorbed by roots, of which the chief are potash, lime, magnesia, nitric, phosphoric and sulphuric acids, and iron salts. Unfortunately, no chemical analyses have been made of the local moorland sands so that we are unable to say what their mineral content is. Graebner gives many analyses of soils which lend

* "Types of British Vegetation," pp. 107-111.

support to the view that those of moorlands are comparatively poor in plant food.* The following analysis of moorland water, taken from Jugger Howe Beck on Fylingdales Moor, we insert because it indicates the character and amount of the mineral ingredients that may be in the moorland sands :—

ANALYSIS OF WATER FROM JUGGER HOWE BECK, BY PROF. TIDY.†

	Grains per Gallon.
Total solid matter	9·10 grains
Ammonia	trace
Nitrogen as Nitrate and Nitrites, Nitric Acid ..	trace
Organic Carbon	·214 parts per 100,000
Organic Nitrogen	·020
Lime (CaO)	1·79 grains
Magnesia (MgO)	·612 ,,
Sulphuric Anhydride (SO) ..	·080 ,,
Chlorine	1·512 ,,
Common Salt	2·478 ,,

An analysis by Professor Attfield of the water issuing from Hazel Head Springs, Egton High Moor, showed the following :—

Chlorides	2·87 grains
Ammoniacal Salts	trace
Carbonate of Lime.. ..	7·22 grains
Sulphate of Lime	·65 ,,
Carbonate of Magnesia ..	·70 ,,
Silica	·70 ,,

What has produced the differences in the soil of the moors, and above all, what has caused that rich accumulation of peat or humus ? Let us imagine a sandstone surface

* " Heide Nord-Deutschlands."

† Quoted by Fox-Strangways in " Jurassic Rocks of Yorkshire," pp. 498 and 518.

exposed to the action of the weather and entirely destitute of plant life. Such a surface, in course of time, becomes disintegrated by the frost, rain and wind ; a sandy layer is formed, passing below into coarser rock fragments until the solid stratum is reached. Numerous sections exhibit this effect of the atmosphere upon the moorland grits and sandstones. Falling upon the sandy layer, the rain dissolves those mineral ingredients already mentioned, and carries them into deeper layers. A poor soil is thus rendered still poorer at the surface, and consequently it becomes still more unsuitable for plants of large and rapid growth which require considerable quantities of mineral food. That this leaching action has taken place on the Eastern Moorlands is certain, for that well-known rock, the Lower Calcareous Grit, which caps the northern edge of the Tabular Hills, has practically no calcareous matter in its surface layers : these consist principally of white siliceous grit, all the calcareous matter having been dissolved and carried away by the rain. Most of the moorland sandstones are somewhat porous, and as they usually rest on shales, the percolating water is thrown up in the form of springs at their base. In this way, for centuries, large quantities of mineral matter have been removed from the weathered surface, and the probability is that the humic or peaty sand shown in Figs. 11 and 12 represents the leached out portion of the rocks.

Whilst the weathering continues, plants begin to settle upon the surface ; though what these plants will be is difficult for us to decide owing to the circumstance that so few bare spaces exist where we can observe the initial development of moorland. Probably the first species to appear are minute algae and mosses which cover the ground with a thin green film, but it is not unlikely that Ling and some of its associates may colonise the surface at the outset. Small sandy spaces occasionally occur where Heather and Purple Bell Heath grow in patches. Shale heaps, such as those in the great alum quarries at Boulby near Loftus, or

the spoil heap at some old moorland coalpit (Fig. 38), have clumps of Ling upon their slopes almost before a trace of humus or other plants appear. Grasses frequently grow on old quarry tippings, such as the Brown Bent (*Agrostis canina*) and the Sheep's Fescue Grass (*Festuca ovina*), but in many cases the vegetation of these bare spaces depends upon their situation in regard to surrounding plants. Still they furnish local indications of the manner in which Heather moorland develops on the bare ground. Undisturbed sandy spots can be observed by roadsides, the surfaces of which are pierced by dwarf shoots of mosses (*Polytrichum*), and, according to Graebner, these plants on the dunes of the Baltic Coast help to consolidate the loose shifting sand and prepare the way for higher plants.*

Whatever plants appear, their remains—leaves, stems, roots, seeds, seed-capsules, etc.—fall upon the sandy soil where they may be subjected to three changes :—they may be completely destroyed by chemical and physical processes, aided by the action of worms and bacteria ; they may undergo a process of oxidation, likewise aided by fungi, bacteria, worms and grubs ; or they may undergo a process of reduction in which the action of the lower organisms is insignificant or totally absent. The resulting product in each case is different. In the first no humus is formed ; in the second mild humus or mould is the result ; in the third, raw humus, peat, or acid humus, accumulates. It is the last process which has operated on the moors, and which is very largely responsible for their existence. Though the other processes have been and still are at work, their destructive influences are counterbalanced and exceeded by conservative influences ; for it is a peculiarity of the process of reduction that it leads to the accumulation of great thicknesses of raw humus which, under favourable circumstances, may be 40 feet deep.

* " Heide Nord Deutschlands," p. 89.

The Fat Moors

The total destruction of plant remains is rare, as the oxidation is very imperfect and chiefly confined to the surface. When the heath vegetation has attained a close growth, it partially shelters the humus from the action of the air. Winds sweep with great velocity over the moors and cause air currents to move amongst the Ling stems (where the plants are somewhat open in growth), and over the superficial layers of humus, and supplies of oxygen are thus brought into contact with those substances in the plant remains which unite with it to form carbonic acid, sulphur trioxide, etc. How effective this oxidation may be is clearly illustrated by the changes that take place in charred Heather stems or "gouldens." At first black, they become in time an ashy grey colour, for their carbon combines with the atmospheric oxygen until the whole has disappeared (Figs. 40 and 49 show grey gouldens in the foreground). Similarly, though more slowly, less effectively, and quite superficially, owing to the continual rain of plant remains and the closeness of the vegetation, the raw humus of the Heather moor participates in the same changes.

But, as already mentioned, oxidation is outweighed by the chemical process of reduction, especially on fat moors and the Mosses. Several causes conspire to exclude oxygen from the peat, viz.: the closeness of the masses of vegetation, the formation of the humus in water, the heavy rainfall, and the general absence of earthworms and grubs of insects. Darwin has shown how earthworms contribute to the origin of vegetable mould by passing through their bodies earth and organic substances, and redepositing them in the form of castings on the surface of fields, gardens, etc. In the course of ages the whole of the surface mould and soil is ejected by worms and exposed to the influence of the weather, oxidised, and converted into mild humus which rarely accumulates to any considerable thickness. This process, however, is entirely lacking on moors, especially fat moors. Worms are

scarce, if present at all, and if stones embedded in peat are turned over, none of these lowly-organised animals will be seen. Only where circumstances favour, on grassy spaces for instance, do they exist. Larvæ of subterranean habits are also more or less absent from acid humus, and the lack of these creatures prevents the mole from living on peaty moorlands. Occasionally these active burrowers will be met with at high elevations, and I have observed them at an altitude of 1200 feet near Ralph Cross ; but wherever thick peat is developed the mole is absent. Anyone who has noticed the work moles can perform in throwing the soil on to the surface must admit they have no little influence in thoroughly mixing its organic and inorganic constituents and exposing both to the weather. Hence the absence or rarity of all these animals on the moors is a further factor favouring the accumulation of plant remains. In estimating the relative importance of these various causes perhaps the greatest weight should be attached to the presence of a copious supply of water, either as rain or in the form of springs. The wetter the moor, the greater the accumulation of humus. Later on we shall see why this is the case.

Schröter and Früh, in their great work on the Moors of Switzerland, emphasise the fact first formulated by the latter investigator, that the co-operation of micro-organisms (microbes, etc.), has had very little effect in the formation of peat.* In any case, the peculiar antiseptic properties of peat exclude the presence of destructive bacteria, and since these organisms play a very large part in numerous processes of decay, their non-existence in the soil of moors favours the accumulation of vegetable remains.

By the co-operation of these several causes, aided probably by others not yet discovered, acid humus collects on the weathered sandy surface. It undergoes a process of

* " Die Moore der Schweiz," p. 128. In this work there is a detailed account of peat formation.

Photo by] FIG. 15.—PIKE HILL MOSS PEAT HOLES, GLAISDALE HEAD. *[Frank Elgee.*

reduction which is just the opposite to oxidation, viz., the removal of oxygen ; and it is doubtless the absence of oxygen which renders raw humus unsuitable as an abode for worms and subterranean larvæ. We cannot deal here with the complex chemical changes which acid peat undergoes. Deficiency of oxygen favours the formation of organic acids which stain blue litmus paper red. These humic acids, as they are called, are decomposable with difficulty, but mix with the moorland water, and obstruct its absorption by the plant roots and root-hairs. They are everywhere present, and may frequently be observed covering the surface of pools with an iridescent sheen. They are usually brown or black in colour. The carbon in the peat forms compounds with hydrogen, the chief of which is Marsh Gas or Methane (CH^4) ; the sulphur also unites with the hydrogen to form sulphuretted hydrogen (SH^2). These changes more properly belong to the peat of moorland bogs with which we shall deal in Chapter IV.

When a shallow deposit of acid humus has accumulated on the sandy surface, pan begins to form in a mode which has been ably elucidated by German investigators* and which has been admirably summarised by Graebner in the work already quoted.† Briefly it is as follows :—

Rain-water percolates through the humus and conveys the humic acids into the soil proper, into that weathered portion which thus becomes stained with peaty matters. The water carries the acids through those layers which are poor in soluble salts, but when it comes in contact with the unweathered soil full of soluble mineral matter it takes this up at the same time depositing the humic acids which knit together the loose grains into a layer of red or brown pan. The process is a very gradual one and the layer slowly in-

* P. E. Muller, " Die natürlichen Humusformen," Berlin, 1887 ; E. Ramann, " Ortstein und ähnliche Secundärbildungen in den Alluvial und Diluvialsanden," Berlin, 1885.

† Op. cit., p. 123-124.

creases in thickness as the humic acids are deposited at the junction of the unweathered and weathered sand.

Such then are the soil conditions of the fat moor, and their mode of origin. These deposits, as we have seen, are produced by definite causes, and it is clear that these causes in their turn must be determined by others, the chief of which is the climate. It is quite obvious that the drier and windier a climate is, the greater will be the oxidation of plant remains, and the less chance, therefore, for the accumulation of acid humus. That moors and heaths are so extensively developed in Western Europe shows that that part of the world is favourable to ericetal plants, and a careful examination of the climatic conditions prevailing in various localities, has, of late years, resulted in the ascertainment of the limits of moor development. We shall, accordingly, next glance at the climate of the Eastern Moorlands, and see how it corresponds with what has been observed in other districts.

The wind sweeps with great force over the comparatively level and exposed uplands of Black-a-more, and is always stronger than on the lowlands. "As an instance of the power of the wind on these moors," says Mr. Fox-Strangways, "we may mention that many of the trees growing on the escarpment of Rievaulx Moor were some years ago torn up by the roots and hurled on to the top of the plateau."* Such powerful winds have a tendency to keep the vegetation dwarfed and shrubby, and generally speaking extensive heather-clad moors are often best developed where the wind sweeps over unobstructed tracts of country. By reason of their short growth ericetal plants are admirably adapted to this climatic condition.

Owing to the elevation, the rainfall on the moors is much heavier than in the lowlands. At Middlesbrough the annual average rainfall from 1884-1908 was 24·16 inches, whilst

* "Jurassic Rocks of Yorkshire," Vol. I., p. 481.

at Whitby from 1867-1908 the annual average was 25.41 inches. Records extending over a short period at Redcar, Scarborough, and other places show that the rainfall there sometimes does not exceed 22 inches in the year. The nearer we get to the hills, however, the higher the rainfall becomes. Northallerton has an average of 25·78, Guisborough with an elevation of 400 feet has an average of 30·83 inches. At Ingleby Greenhow, at the foot of the Cleveland Hills, the average for sixteen years (1884-1900) was 31·18 inches. At the Lockwood Beck Reservoir, which is on the northern edge of the moors at an altitude of 589 feet, the average annual quantity of rain from 1873-1908 amounted to 32.64 inches, and for twenty-two years out of the thirty-six, the annual amount was over 30 inches.* In the heart of the moorlands it is reported to be as high as 36 inches, and the probability is that in some areas, the central watershed for instance, it is even greater than this. Over the whole moorland region the average probably lies between 32 and 36 inches per annum, an average 7 to 11 inches higher than at many places on the plains.

These facts are in complete consonance with those detailed by Graebner, in his " Heide Nord Deutschlands," concerning the relationship of the North German heaths to the rainfall of North Germany generally. As the dependence of the ericetal vegetation on climatic factors is very distinctly brought out by these researches, it will be necessary to dwell upon them for a short space.

Although the soils of the North German plain are the same in the east as in the west, yet the vegetation of the two areas is quite distinct. In the west, in Hanover, Oldenburg, and Schleswig-Holstein, are great stretches of Heather moorland, whilst in the east these are entirely absent and are replaced by thin pine-woods and a steppe-like flora. This difference is due in part to the different climate of the

* I am indebted to the Secretary of the Cleveland Waterworks for these statistics.

two areas. In the main " Heide " area, which is west of the Elbe and passes northwards into Holstein, the rainfall rarely falls below 24 to 28 inches per annum, whereas in the east and especially in the basins of the Oder-Weichsel, the rainfall often does not exceed 20 inches per annum. Along the Baltic shores there runs a strip of heath vegetation, and it is worthy of note that this occurs continuously where the rainfall is at or above 24-28 inches ; but at the mouths of the Oder and the Weichsel, where it is less, Heather moors do not occur. Similarly, the Lausitz Heide, south of Berlin, possesses a minimum rainfall of 24-28 inches per annum, although surrounded by country uncovered with heaths and with a much lower precipitation.*

Neglecting other atmospheric factors on which Graebner lays stress, it is obvious from the data which he has collected that the full development of moorlands cannot be attained with a rainfall less than 24-28 inches per annum. The greater the rainfall, the greater the accumulation of humus and pan. The rainfall of the Eastern Moorlands is considerably higher than that of the German " Heide " area, and consequently helps very considerably to produce those necessary soil and moisture conditions upon which their existence depends.

It is not yet definitely known what is the upper limit of rainfall under which Heather moors can flourish, but their scarcity in parts of the country where the rainfall exceeds 60 inches per annum is regarded as having a real significance.†

Altitude is a secondary factor in determining the existence of moors, by increasing the rainfall, lowering the temperature, and increasing the velocity of the wind. In North-Eastern Yorkshire, the highest moors occur at an elevation of 1489 feet, the low moors of the Howardian Hills are only 250 feet above the sea, and still

* Op. cit., pp. 128-134.

† Tansley, " Types of British Vegetation," p. 99.

lower heaths exist in the Vale of York. On the coast at Saltwick Bay near Whitby, and at Peak, moorland plants descend almost to high-water-mark. Why the Eastern Moorlands occur at their present elevation will become apparent when we deal with their geological aspects.

Fogs and clouds often hang over the uplands when other parts of the district are clear. In winter, the moors are always more or less soaked with moisture, and are, in places, impassable. After rain in summer, when the surface water is being evaporated by the hot sun, a curious phenomenon is produced, known locally as "summer geese or colts." If the moor edge be projected against the skyline, water vapour can be seen flowing and quivering in dark waves over the top of the Ling. "See how the summer colt rides," as they say in the dales.

Such being the physical and climatic conditions of the moors, it remains to be pointed out how the plants are enabled to live under them. Not that we propose to enter fully into the question of their adaptations; this lies beyond the scope of these pages. All that will be needful is to show how they manage to obtain their sustenance under circumstances which are certainly adverse to most species from other habitats. Having done this we shall have a *raison d'être* for the existence of the moors.

As proving how other plants cannot live upon peaty soils, it is instructive to observe that on swiddens, ericetal species alone appear. Seeds of all kinds of plants must be deposited on these blackened areas, either by the wind or by birds and insects; but none of them ever attain even the form of seedlings, and must therefore perish owing to the conditions not being suitable for their existence. Definite proof that the seeds of plants found on waste spaces—ruderal plants—settle upon the moors, is furnished where the ground has been radically disturbed and the soil consequently changed. Thus, Nettles may be found growing upon artificial soil consisting of cinders and sand, by the side of

the Rosedale Branch Railway at Farndale Head; and, where shooting boxes have been erected, the same species will be seen. By roadsides, where scrapings and gutter refuse have been banked up, ruderal plants occur—Thistles, Nettles and the like. Not being provided with those special adaptations which true ericetal species possess, they cannot maintain themselves upon the peaty soil of moors.

The moorland vegetation is more or less in the position of the Ancient Mariner "with water, water everywhere, nor any drop to drink." Both they and the Ancient Mariner live under a condition which is known as physiological drought. That is to say, although they are surrounded by water it is unassimilable and they might almost as well be living in a desert! Physiological drought on a wet moor does not coincide with physical drought, but this is so on very dry and sandy heaths. In the first case, the water, being charged with humic acids which act injuriously upon the living plant cells, can only be absorbed in small quantities whenever it is fairly pure, just as the Ancient Mariner would absorb what he could from a passing shower of rain. In the second case, there is not the quantity of water available, peaty acids being, on dry heaths, comparatively scarce. As the plants flourish in situations which are usually windy or liable to be exposed to insolation, i.e., to the full blaze of the sun, it is obvious that owing to the small amount of assimilable water, they would rapidly wither unless there was some check on transpiration from the surface of the leaves. Now the most striking feature of the leaves of moorland plants is their small, almost minute size. The leaves of Heather are only one-sixteenth of an inch in length; those of the Heaths are slightly larger; and those of the Crowberry are about a quarter of an inch. By this device the transpiration area is very considerably restricted; but more than this, all the leaves mentioned are inrolled; that is to say, their edges are rolled inwards towards the under

surface, so that a small slit is left between the opposite edges. The whole leaf thus forms a narrow cylinder, beautitully illustrated in the Crowberry, where not only is the leaf a perfect cylinder but the slit is practically closed by interlacing papillae. Within the slit are the transpiration pores or stomates, protected in this way from all outside influences. Water cannot get at them, the wind cannot sweep over them; and so by this remarkable adaptation the loss of water is reduced to a minimum. In many moorland grasses and sedges this type of leaf structure is well-displayed. We see it in the fine thread-like and tubular leaves of the Sheep's Fescue Grass, the Wavy Hair Grass, the Mat Grass, in the Tufted Scirpus (*Scirpus cæspitosa*), in the Cotton Sedges, etc. There are exceptions to this rule into the details of which we cannot enter, but the leaves of Sweet Gale, Bilberry, Flying Bent and other species are not inrolled, and possess other characteristics which render them capable of living under the same conditions of life.

The evergreen character of the Heather is not regarded by Schimper as an adaptation to the environment, but as a morphological feature due to heredity, and it merely dominates the whole formation because of the dominance of the Ling itself.*

According to the same authority it is still an open question as to what extent moorland plants need the organic substances in the acid humus or are restricted to it because they can endure it. The mineral matters in the humus though full of materials essential as plant food, are in such a form as to be directly unassimilable by the roots. Several species—Heather, Heaths, Crowberry, etc.—have their roots and root-hairs enveloped by a fungus whose cellular mycelial threads are in intimate contact with the cells of the plants. By a process peculiar to this fungus or micorrhiza, the organic compounds in the humus are broken down and

* "Plant Geography," p. 657.

passed on to the heath plants, which would thus appear to be unable to obtain their food from the soil without the assistance of the micorrhiza, one of the most remarkable instances of symbiosis known, for it dominates such wide areas of the earth's surface.

In this chapter we have examined the typical moor or heath of North-Eastern Yorkshire ; we have also examined those essential conditions of soil and climate under which it flourishes ; and we have briefly glanced at the adjustments of the plants in relation to their environment ; but variations set up by local circumstances give rise to types of vegetation with soils which diverge considerably from those we have described.

Photo by] FIG. 16.—YARLSEY MOSS, GLAISDALE HEAD. *Frank Elgee.*

CHAPTER III

THE THIN MOORS

INSENSIBLE gradations connect the fat moor with the thin moor. In passing from the one to the other we notice that the humus becomes shallower, the Ling less luxuriant, and the ground generally much drier. At the same time other plants appear amongst the Heather, and, owing to the thinness of the peat, stones frequently litter the surface and project above the vegetation (see Fig. 39). Grasses occasionally play an important part on the drier moors, and are probably indicative of somewhat better edaphic conditions; not that the soil is actually any richer in plant food than that of the fat moor, but the decreased quantity of raw humus and frequent absence of pan render assimilation much easier for plants, as their roots strike into the sandy soil without hindrance.

A few thin moors are wet, and these are most closely related to the fat moor. Two kinds may be recognised—the Calluna-Nardus moor, and that dominated by the Tufted Club Rush (*Scirpus cæspitosa*).

Parts of Danby Low Moor above Castleton may be taken as typical of the first group. The Heather is interspersed with tussocks of Mat Grass (*Nardus stricta*), the Pink Bell Heath, the Heath Rush, and Reindeer Lichens. These plants grow on a peaty sand quite distinct from the rich humus of a fat moor, and no trace of pan can be detected in the sections exposed.

The second type of wet thin moor is very distinct and rare in North-Eastern Yorkshire. It occurs in badly-drained localities, and is much damper than the Nardus moor, while the humus is shallow and often rests upon clayey

shale. The two principal plants are the Tufted Club Rush (*Scirpus cæspitosa*) and the Pink Bell Heath, usually in about equal proportions, though sometimes the one and sometimes the other preponderates over its associate. The most extensive spreads of these plants known to me are at the head of Lockwood Beck on Stanghow Moor. Other frequent though subordinate species are the Cotton Grass (*Eriophorum vaginatum*), the Flying Bent (*Molinia cærulea* var. *depauperata*), the Heath Rush (*Juncus squarrosus*), and the Common Rush (*Juncus conglomeratus*). The surface of the soil is hummocky, and on the hummocks grow those plants which characterise this very distinct kind of moor. We may further emphasise its features by remarking that such familiar species as the Mat Grass, the Bilberry, the Crowberry, and the Purple Bell Heath are totally absent.

Intermediate between these two associations is another which occurs on Hutton Mulgrave and Egton Low Moors, particularly on the former, where the Pink Bell Heath is the principal plant followed in order of abundance by Mat Grass, the Tufted Club Rush, and the Cotton Grass (*Eriophorum vaginatum*). So far as my observations go, moors on which *Scirpus* plays a prominent part only occur on the northern side of Eskdale. Elsewhere in the country, the Scirpetum, as this association is sometimes called, exists on deep peat as in the Wicklow Mountains to the south of Dublin, in the north-west Highlands of Scotland, and in Shetland.* *Scirpus*, as we shall see in the next chapter, is a conspicuous element on a peat bog in Kildale, but the floral composition of the Scirpetum in such localities differs appreciably from those we have just described.

As previously stated most thin moors are dry, and they exhibit a somewhat extensive series of plant associations ranging from pure Heather moors to grassy commons, with little or no Ling in their vegetation, and corresponding

* "Types of British Vegetation," p. 272.

closely to the heaths of southern and eastern England. The thin Callunetum is particularly interesting, for like the fat Callunetum, it consists almost exclusively of Heather, but differs in being comparatively dry and in the short growth of the dominant plant. Perhaps the best example I have met with occurs on the summit of a ridge on Danby Low Moor, above Danby End. This ridge, Elm Ledge, 850 feet above the sea, marks the outcrop of a porous sandstone, the Kellaways Rock (see Figs. 42, 43, and 44). On the summit the ground has a gradual inclination towards the north and is clothed with short Heather. A section in the soil shows that peat properly so-called is absent, being replaced by sandy humus underlain by a coarser sand at the base of which is a thin layer of pan.

The peculiarities of the Kellaways Rock moor were recognised in the Geological Survey, and Mr. Barrow remarks: "It is possible to tell at night when crossing a driftless area of Kellaways Rock, both from the extremely short Heather with which it is covered, and the peculiar scrunching of fragments of rock under the feet."* The fat moor on wet clayey shale, described in Chapter II., occurs in proximity to the thin moor of the Kellaways Rock, so that at one moment we are on a dry thin moor and at another on a wet fat moor, the boundary between them being fairly well-defined.

Here we have distinctly illustrated the influence of the underlying rock upon the character of the vegetation, a cause generally in operation, though often obscured by other conditions. The formation of peat, for example, effectively masks the direct action of the true soil. On the Kellaways Rock of Allerston High Moor, between Sleights and Pickering, at an elevation of about 950 feet, we find instead of the dry thin moor we should expect, peaty Heather moors with much Bilberry, and this anomaly must

* "Geology of North Cleveland," p. 58.

be attributed to the circumstance that the ground is badly drained, causing accumulation of peat on which Heather flourishes far more vigorously than on a sandy humus.

Great Ayton Moor is an excellent example of the heath of North-Eastern Yorkshire. Here we find thin humus lying upon the flat surface of a sandy and stony soil. Traces of pan may be observed in the roadside sections, and though not nearly so strongly developed as on the fat moors, it probably underlies all the thinner heaths of this type. Botanically the heath must be regarded as a Callunetum, for Ling is dominant, but the Bilberry, Crowberry, Purple Bell Heath, and the Common Tormentil (*Potentilla tormentilla*) occur sporadically. Large spreads of Reindeer Lichen interspersed with allied species (*Cladonia uncialis, coccifera*, etc.) are also well-displayed. In wetter hollows the Common Rush (*Juncus communis*) is numerous, in company with the Heath Rush (*Juncus squarrosus*), Bog and Hair Mosses. Wherever the Heather closely grows few species manage to live amongst it, especially when the plant is in its prime ; but when old age creeps on, the Ling becomes straggly, the stems fall away from one another, and a space is left in the centre of the clumps. Mosses, principally that fine species *Hypnum cupressiforme* var. *ericetorum*, colonise the bottom of this space, *Cladonia* Lichens also settle, and fine groups of Cup Lichens (*C. coccifera*) may be observed. On the stems themselves another plant makes its home, the handsome Inflated Lichen (*Parmelia physodes*) with its bleached appearance and curled form. I have occasionally noticed perfect rings of Heather with a tuft of Heath Rush or other species flourishing in the centre ; and I think we may explain this by aid of the facts just mentioned. It is quite likely that after a time the centre of a clump of old Ling becomes colonised by a flowering plant, round which the young Heather springs up.

On the Tabular Hills thin Heather moors are frequent at the edge of the escarpment ; but the vegetation varies

in places owing to variations in the water content and the character of the underlying rock, the Calcareous Grit. On the noble promontory of Birk Nab, at an elevation of 1000 feet between Sleightholme Dale and Riccal Dale, Heather is dominant, and interspersed with Crowberry and Purple Bell Heath. The humus is thin, somewhat dry, and underlain by a mass of small stones out of which all traces of calcareous matter have been dissolved by the rain. Further south, the thin moors of the Tabular Range merge into grassy commons and whin coverts, as at Boonhill and elsewhere.

As long ago as 1796 Marshall recognised the different nature of these moors, and it will not be without interest to quote his description of the Eastern Moorlands :—

" The natural produce of the more lofty swells of these mountains—termed provincially the ' high moors '—is principally Heath, interspersed with patches of ' Bent ' ; together with the common rush and other aquatics, in the valleys, and on the bogs with which even some of the swells abound.

" But, at the foot of those swells, and in the faces of the cliffs which terminate them to the south (the Tabular Range), as well as upon the top of the marginal heights—which, when they shoot far to the northward as between Newton and Cawthorn, are covered with black soil and heath—a number of the better grasses, with a variety of other plants, may be found growing among the heath, notwithstanding the situation which in point of blackness is little inferior to the ' moorheads.' "*

All the moors of the Tabular Hills are not thin ; on the contrary, some of them are very fat, and in places form true Mosses as we shall see in the following chapter ; but, with the exception of Arden Great Moor, Black Hambleton, and parts of Allerston Low Moor, thick peat is rare,

* " Rural Economy of Yorkshire."

and even in the localities named it is never so deep as on the moors of the central watershed. A well-marked feature of the summit of the Tabular Hills is the tendency for trees to spring up amidst the Heather. This is perhaps most marked along the southern edge of Rievaulx and Helmsley Moors, where hundreds of self-sown pines from the neighbouring plantations flourish for a distance of almost half a mile to the north, becoming few and far between as the edge of the escarpment is approached.

The transitions between the thin Heather and the Grass moors are well-displayed towards the moor edges in most parts of the district ; and the high ridges of land which divide the dales opening into the Esk Valley afford admirable illustrations of these transitions. Where they radiate from the watershed, the land is mostly fat moor ; but lower down the " riggs " the moor becomes thinner and thinner, partly owing to the decreasing rainfall due to lessened elevation and partly owing to the better drainage along their slopes.

On Danby Ridge above Ainthorpe, the Heather is mixed with Mat Grass, and Gorse bushes are numerous. The Ling is still dominant but somewhat stunted, and on the lower and steeper slopes it becomes rarer, being either superseded by Bracken and Bilberry, or by Grasses and Furze. On the gentler slopes of the Ridge, Bracken puts in an appearance, a fact showing that on these inclinations it has a tendency to assert itself wherever the slightest opportunity offers. The damper parts of the " Rigg " are dominated by great spreads of the Heath Rush mixed with Mat Grass and Bracken.

A remarkable swidden of a somewhat rare type was observed here in early June when the vegetation was in marked contrast to that of the surrounding moor. Upon the burnt space were innumerable clumps of vivid green Crowberry interspersed with large spreads of the reddish Sheep's Sorrel (*Rumex acetosella*)—a small species of dock—

thus presenting a unique facies and a brilliant contrast of colours.

The steep slopes below High Castleton are a good example of thin moor in a more advanced state of development towards sward. Heather is present, but grasses prevail; and the Mat Grass, the Sheep's Fescue Grass, the Wavy Hair Grass, and the Common Bent occur in profusion.

This type of vegetation is somewhat rare in North-Eastern Yorkshire. On the Eston Hills in the extreme north of the area are extensive swards of coarse Mat Grass with here and there a wider spread of Ling, the Crowberry is also abundant, perhaps more so than elsewhere.

Easby Moor, on which Captain Cook's Monument stands, is covered with a vegetation that is half Heather and half Mat Grass, both species being very equally mixed with one another. The moor is extremely thin, and the stunted plants grow in a few inches of humic sand which passes below into weathered fragments of rock. The paths are large and well-defined owing to the constant stream of visitors to the monument, and an examination shows the turf is composed of Sheep's Fescue Grass, the Brown Bent, and the Early Hair Grass as well as other species much less abundant. It is to be noticed that the Mat Grass flourishes on both wet and dry thin moors, but it always attains, in North-Eastern Yorkshire at any rate, its most luxuriant development on the former. But the moor must not be too wet or too peaty otherwise the plant is ousted by species better adapted to such conditions.

Among the Grass Moors we may mention the Howe at Castleton (Fig. 54), which is a conspicuous hill dividing Danby Dale into two sections at its exit into Eskdale. Here we find Mat Grass the dominant plant, especially in a broad zone round the middle of the hill. On the lowest slopes Furze is plentiful, and scattered dwarf bushes creep some little way up the sides. Above the Furze belt dwarf Ling is abundant, in places sharing the ground with

Nardus. The Ling disappears about half-way up, and on the summit Bracken becomes sub-dominant with a patch or two of Heath Rush. Dwarf Bilberry is not infrequent in the lower zones, and a special feature of this moor are bosses of moss (*Dicranum scoparium*, etc.), associated with Reindeer Lichens through which a few Bilberries push their wiry and angular stalks. Besides the above-named species, there are many others on the Howe, but it would be tedious to enumerate them in detail. Anyone can perceive that this kind of thin moor is radically distinct from the pure Heather moor, but, as we have before noticed, insensible transitions unite both extremes.

The reader will have observed that Furze (*Ulex europæus*) occurs on these moors, and in some parts of the district it constitutes with grasses, an almost separate type of vegetation. On Cockshaw Hill above Great Ayton, Gorse and Heather in varying proportions form an easily distinguishable plant association. As usual, ericetal grasses (*Nardus, Aira flexuosa, Festuca ovina*, etc.) occur abundantly amongst the Ling. Near Stanghow, there is another example of this association where Gorse is even more dominant. This association usually characterises the moor edge, as in the neighbourhood of Staintondale, and is generally indicative of drier conditions and a soil where deep humus is practically absent. Gorse is a conspicuous element in the plant life of the slopes which we shall describe later ; our observations in this chapter are restricted, wherever possible, to the flat moors.

Professor E. F. Weiss in a paper on " The Dispersal of Fruit and Seeds by Ants "* has described a very interesting circumstance with regard to the distribution of Gorse on the Eastern Moorlands. He refers to the incursion of Furze bushes into pure Heather moor between Rievaulx Abbey and Coxwold, particularly above Wass Bank. Plants

* " New Phytologist," 1908.

Photo by] FIG. 17.—PEAT AT LOOSE HOWE. *[Frank Elgee.*

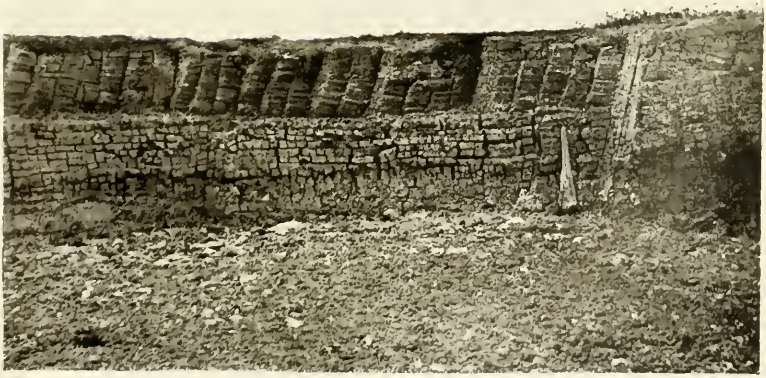


Photo by] FIG. 18.—PEAT IN COLLIER GILL, WHEELDALE. *[Frank Elgee.*

occur on either side of the main road, and diverge in long lines into the Calluna moor. I have observed similar rows of Gorse running in comparatively straight lines in many parts of the district—on the Howe at Castleton and on Danby Ridge for instance. As Dr. Weiss states, the lines are almost invariably on the site of old or little used cart tracks, and he attributes the arrangement of the plants in this manner to the influence of ants. Investigations have proved that the seeds of many plants are furnished with an edible portion, the caruncle, often brightly coloured, which ants esteem as food. Hence such seeds are eagerly sought after and carried away by the insects. Some, however, drop by the way, and if the soil is suitable, germinate. As a method of dispersal this is an established fact, and as Furze seeds possess a bright orange caruncle, the probability is that the plant is thus distributed. Ants use old tracks in getting to and from their nests, and when carrying the seeds of Gorse, they may have distributed them into the Heather moors in almost straight lines. Ants, as we shall learn later, are very abundant on the moors, and may, therefore, be an important agent in plant dispersal. The facts cited are, however, capable of another interpretation. That the Gorse clings to the borders of old cart tracks suggests that seeds were enabled to flourish along the line of the road owing to the disturbance of the raw humic soil which always takes place by roadsides. For, quite apart from any banking up that may be done, the wheel ruts are a channel for running water, and in these ways the soil is much mixed with sand and mud. Furze often fringes the highways, but nearly always towards the margin of the moors, rarely in the heart of the district—due, I think, to the more favourable soil conditions and thinner character of the moors in the former localities. Thus it is quite possible that soil conditions alone may have determined this singular instance of distribution. Furze may often be observed growing along the slopes of ditches or

hollows in fields ; and near the railway bridge on the road from Castleton to Danby End, bushes can be observed growing round the base of wooden posts about six feet apart. It would not be safe to say definitely what factor or factors have given rise to these curious dispersals.

If the distribution of Gorse and other species is in part effected by ants, we have a remarkable instance of the relationship between the ericetal plants and the animal life of the moors. No feature of plant distribution on the moors can, therefore, be regarded as trivial or unimportant, since its explanation may lead to the discovery of obscure causes and involved dependencies of one being upon another.

Returning once more to a consideration of the types of thin moor, we must glance at one or two examples of the sward, common, or grass heath as they are variously called. Strictly speaking, they are not moors in the northern sense of the word, but a few remarks are necessary concerning them as they represent the final disappearance of heather-clad lands into plant associations of a non-ericetal character. Extensive swards do not exist upon the moors, yet we frequently come across small grassy spaces which, from various causes, have almost and sometimes quite ceased to support Ling. I remember examining such a sward on the northern side of Stockdale on a fine September day. The turf, consisting of the Sheep's Fescue Grass, the Brown Bent and the Early Hair Grass, was short and smooth, and surrounded by Bracken and Heather. On the sward were beautiful clumps of bright green Hair Moss (*Polytrichum communis*), of a brighter green even than the turf itself ; here were the bristly leaves of the Heath Rush, there tufts of greyish Mat Grass with occasional bosses of purple Ling, the whole presenting a very pleasant aspect when contrasted with the dark moors on every side.

Were we to define a moor as land on which Heather grows, Spaunton Moor between Sinnington and Kirby Moorside in the Vale of Pickering would merit that name. On the

summit of the low hill on which the moor is situated, are small patches of extremely dwarfed Heather barely an inch in height. So small is the plant that careful searching is necessary in order to discover it. In reality Spaunton Moor should not be so called; it is a fine grass covered common with an abundance of Gorse; and the soil is derived from the shales of the Kimmeridge Clay, peat is absolutely wanting, and there is no pan.

The rarest kind of grass moor in this district is that on which the Purple Moor Grass or Flying Bent (*Molinia cærulea*) prevails—the Molinietum. In the preceding chapter it was pointed out that this species has a tendency to appear on certain fat moors of the North Cleveland watershed, and in a few localities towards the boundary the grass becomes quite dominant, though never covering any extensive area. Just east of Freeborough Hill (Fig. 57), near Moorsholm, we find a good example, where in a slight hollow great tussocks of the grass, occasionally nearly three feet high, cover the damp ground in profusion. The Heather is subordinate with the Decumbent Heath Grass (*Triodea decumbens*), Tormentil, the Wavy Hair Grass, Yorkshire Fog (*Holcus mollis*), and Tufted Hair Grass (*Aira cæspitosa*). Where *Molinia* is thinner Mat Grass comes in. The Wavy Hair Grass with its handsome reddish culms forms, here and there, luxuriant carpets; the Brown Bent with its feathery panicles is also luxuriant, and the Sweet Scented Vernal Grass (*Anthoxanthum odoratum*)—a species also found in fields and lanes—is plentiful. Towards the south, on a slight rise, is a thin moor with Heather, Rushes, Pink Bell Heath, *Molinia* and *Scirpus*. The soil is somewhat peaty and wet. Altogether the vegetation is most heterogeneous, and gives the impression that the ground has formerly been under cultivation, the remains of hedges or old walls being traceable. Occasional trees suggest that it has also once been the site of a plantation.

Wherever thin moorland has been reclaimed and then

neglected, it degenerates into grass heath. This is very noticeable in the neighbourhood of Osmotherley near the Chequers Inn, and in the upper parts of Ryedale near Snilesworth. It seems a pity that waste land reclaimed at so much labour and expense should be allowed to deteriorate, though perhaps it was scarcely worth the outlay of time and trouble, for such enclosures cannot be highly cultivated, and are mostly used for sheep.

We may now tabulate the different types of moor described in this chapter as follows :—

Heather and Mat Grass—Calluna-Nardus Moor.
Pink Bell Heath, Club Rush, and Mat Grass Moor.
Club Rush and Pink Bell Heath—Scirpetum.
Flying Bent Moor—Molinietum.
Heather Moor, stunted.
Heather, Grasses and Gorse.
Grasses and Gorse—Commons.

None of these associations occupy a wide area, and as a rule, they prevail towards the moor edges in most parts of the district where the land is comparatively level, where the rainfall is less, the altitude lower, and the rock soil somewhat different from that of the central elevated region. The Nardus Heaths approximate to the siliceous grassland of the Pennines, but on the Eastern Moorlands they constitute no decided botanical feature, and they are usually much mixed with Ling. No hard and fast lines can be drawn between the different kinds of thin moor ; in all directions they merge into one another as slight changes of conditions first favour one species and then another ; and this indefiniteness of transitions prevents definite generalisations. The extremes are easily recognised, but the means are ever varying in character.

With respect to the origin of thin moors, many must have originated on the bare ground in the manner indicated in the last chapter. Others may occupy the sites of degenerate woodland, though of this we cannot at present be certain.

CHAPTER IV

THE MOSSES

IN this chapter we have to describe the transition of the pure Heather moor through wetter and wetter conditions until it merges into the moorland bog or Moss, the reverse of the transition traced out in the last chapter. Many Mosses come under the term fat moor, but as they present so many peculiar features, and throw much light on the botanical history of the heath vegetation, they are best dealt with separately.

It is on the back-bone of North-Eastern Yorkshire—the elevated watershed dividing the drainage of the River Derwent from that of the Esk—that we find the most extensive and most typical development of the Mosses. If we stand on any of the isolated Howes which form such conspicuous landmarks on the high moors, Shunner Howe, Cock Heads, or Loose Howe (Fig. 40), we have on all sides a wide expanse of bogs. The words wild and lonely, as applied to the district of the watershed, convey but an inadequate idea of its aspect. Profound silence generally reigns over these solitudes, broken only by the strife of winds, or in summer by the call of the marsh birds. Owing to the comparative flatness of the ground, its excavation into shallow depressions, and the much heavier rainfall, these moss moors are necessarily very wet at all times of the year, especially in winter, as may be expected. Consequently, they support a suite of plants differing from those of other moors, not so much in its component species as in their relative abundance. Peat of great thickness accumulates and what is sporadic on drier moors, little pools full of Bog Moss with patches of Cotton Grass, is the permanent condition

of the Mosses. The wet types of vegetation already described are transitional stages leading to the moorland bog, which present as varied facies as do other moors. In dealing with these interesting and little studied aspects of nature, we shall follow their distribution along the watershed from east to west.

The first Moss which we shall describe is that of Harwood Dale, at an elevation of six hundred feet, near the Falcon Inn, on the Scarborough and Whitby high road. Though not specifically called a Moss—the place is more usually termed the Harwood Dale Peat Holes—the bog corresponds in all its characters with moors bearing that designation. It measures about the third of a mile across from north to south, and from east to west the distance is approximately the same. The Moss lies in a slight depression south of the watershed which here forms the moors of Stony Marl Howes and Peak, and exhibits that almost universal feature of peat bogs, being higher in the centre than at the periphery, a feature that has resulted in their being called " Hochmoore " in Germany. This Moss has been most extensively excavated for its peat which, in the middle, cannot be much less than thirty feet thick, but it thins out towards the south and round the margin. No remains of trees appear to exist in the central peat, but nearer the high road their stumps are somewhat numerous with roots penetrating into the rock soil. Birch is the principal species. Our photograph (Fig. 14) shows, however, the overturned trunk of a Scots Pine (*Pinus sylvestris*), a tree of very rare occurrence in peat beds of any kind in North-Eastern Yorkshire. In fact, this is the only authentic instance known to me.

The surface vegetation consists of Ling and Cotton Grass (*Eriophorum vaginatum*) in equal proportions though in parts the Sedge dominates with much Sphagnum, indicative of the wetness of the ground. Towards the northern margin Purple Moor Grass (*Molinia cærulea*), with some Pink Bell Heath (*Erica tetralix*) is abundant. This plant

association is distinctly marked off from the surrounding moors which are almost exclusively dominated by Heather on shallow humus.

Perhaps one of the most striking and most extensive of the upland morasses is May Moss on Allerston High Moor, lying two miles to the east of the Saltersgate Inn on the Sleights and Pickering high road. A vast peat bog, May Moss presents features of unusual interest, and is situated near the heart of that wilderness of heather-clad land between the Murk Esk River and the sea-board. Northwards extend the great moors at the head of Iburndale, and to the south rises the cone of Blakey Topping (Fig. 47), with the bold escarpment of the Tabular Hills behind. The bog lies exactly on the watershed, 825 feet above sea-level, and is the source of Eller Beck, a tributary of the Murk Esk, and of two or three small streams whose waters ultimately fall into the Derwent at Langdale End. Seen from the north, the Moss lies in a decided though shallow depression. On the east is the ridge of High Woof Howe, which sweeps round to the west and bounds the bog on the north at Worm Syke Ridge. This latter ridge is broken by the narrow valley of Eller Beck, on the western side of which the ridge continues as Loose Howe Rigg (not to be confounded with Loose Howe at Rosedale Head). Southwards and westwards the land falls away gradually to the foot of the Tabular Hills. The centre of the Moss is considerably higher than the edges, perhaps ten feet, if not more. This elevation of the centre of Mosses is not due to the form of the rock floor upon which the peat has accumulated ; on the contrary, it is entirely due to the manner of growth of the peat itself, the floor perhaps, being concave or sloping. An inverted shallow saucer gives a good idea of this peculiarity of form.

How thick the peat is at May Moss has not yet been ascertained, but judging from similar deposits on the high moors, we are safe in saying that it cannot be less than ten, and not much more than thirty feet deep in the middle. Artificial

drains cutting down to a depth of four or five feet near the northern edge show peat without tree remains resting upon a somewhat clayey soil. Except in a few places, the Moss can be traversed in every direction in the summer, for though very wet at the surface, it is solid peat throughout.

Botanically, May Moss must be classed as a Tetralix moor, for the most abundant plant which grows upon it is the Pink Bell Heath (*Erica tetralix*). Heather and Cotton Grass (*Eriophorum vaginatum*) are much less numerous though otherwise fairly abundant. In consequence, the Moss presents a series of colours at different times of the year. In early summer it is lightly snowed over with the white "Floss Seaves"; in July it becomes a beautiful pink with the flowering Heath; and before this has disappeared the purple Heather blooms. Abundant as the Bell Heath is, it is not so gregarious as its allies, the plants are always more or less separated from one another by slight interspaces. Amidst these species and literally soaking wet, is a vast carpet of Sphagnum of many kinds and colours, red, green and yellow. Moreover, the mosses themselves are often tinted red with the extended rosetted leaves of the Sundews (*Drosera rotundifolia*), insectivorous plants that are very abundant on all the wetter moors.

Leaving May Moss, and travelling westwards for about ten miles, the next moors of the same general character which we meet with are at the heads of the Egton Grange Valley and Glaisdale. Here, at an elevation of 1070 feet, and on the broad flat watershed between the two northern dales and Wheeldale Gill, are Pike Hill Moss and Yarlsey Moss (Fig. 16). The easiest way to reach them is to walk four or five miles along the road from Glaisdale to Rosedale. When near Winter Gill, far away over the moor to the left, a dark brown streak can be seen against the slight slope rising to the distant eastern moorland ridge. This streak marks the site of the Pike Hill Moss Peat Pits. By taking a rough cart track sunk deep into the luxuriant fat moor, we

Photo by FIG. 19.—COTTON GRASS (*Eriophorum angustifolium*) IN FRUIT, DANBY DALE, JULY 1909. *Frank Elgee.*

arrive at the peat and at the heart of Pike Hill Moss itself (Fig. 15). The face of the peat cutting is from six to eight feet high, the hard white Moor Grit forming the surface rock, boulders of which lie scattered over the black, miry ground at the base of the section. Upon this surface are rectangular blocks of peat drying in the air and sun. Here and there they will be found stacked in pyramidal " rooks," the blocks being so arranged as to permit the air to circulate freely amongst them. The peat pits are saturated with water ; it stands in pools at the base of the section ; it trickles down the face of the peat, and one's boots are almost sucked off the feet by the black, spongy puddle. We thoroughly realise the wet character of the Moss, partly due to the heavy rains, and partly due to the water-retaining power of the peat.

The Pike Hill Peat Holes are extensive, and the cutting which is in the form of a semicircle can be followed for half-a-mile or more. In surveying this section, we feel convinced that when investigated such a thickness of raw-humus must illuminate the problem of the origin of the Moss, and the succession of plants which formerly occupied its surface. Its plant association differs considerably from that on May Moss, the dominant species being Ling and Cotton Grass (*Eriophorum vaginatum*), the former being the more abundant of the two. Pink Bell Heath and Sphagnum are frequent, but not nearly so numerous as on May Moss.

The detailed investigation of peat in Cleveland has yet to be made before we can actually trace the succession of plants which compose these singular geological deposits. Nevertheless, a brief inspection of the Pike Hill peat shows that it is quite destitute of tree remains. We conclude from this fact that at the time the Moss began to form, the site was not wooded, and that the moor has either developed on the hard moorland grit, or originated in large pools of water.

Yarlsey Moss (Fig. 16) is a westerly extension of Pike Hill Moss, the two really constituting one huge moorland morass, filling a slight depression two miles long and one mile wide. The former bog has features of its own. Instead of being a Tetralix Moor or a Cotton Grass Moor its surface is clothed with tall Rushes, principally *Juncus communis*, clearly seen in the illustration. Underneath and between the tall plants are extensive beds of Sphagnum, very wet and dangerous to traverse. At intervals no rushes occur, and then the typical Sphagnum Bog—the Sphagnetum—displays its treacherous nature. Why Rushes should dominate here, Cotton Grass and Ling on Pike Hill, and Pink Bell Heath on May Moss, are botanical problems not easily answered. Surrounding the two Mosses are magnificent fat moors clothed with finely-grown Heather, and bright carpets of green and red Bilberry. In the case of Yarlsey Moss the junction between the two kinds of moor is very distinct, the Heather and Rushes forming a clear line with here and there a tongue or promontory of Ling penetrating far into the heart of the morass. Unlike the two preceding, these Mosses do not exhibit any marked convexity of outline, but are almost flat.

South and east of the elevated ridge between Glaisdale and Great Fryup, known as Cock Heads, lie some very extensive moss moors whose vegetation consists chiefly of Heather and Cotton Grass, though where the moor has been burnt the sedge prevails, owing to the resistance its stout rootstock opposes to fire. At an elevation of about 1250 feet, the peat, nearly six feet thick, is composed of Sphagnum, and on the floor of some peat holes Ling grows most luxuriantly, and sometimes patches of the Heath Rush occur with encircling rings of Heather.

The head waters of Wheeldale Gill rise in the Cock Heads Peat Moss, and if the tiny rivulets are followed downstream, we meet with some of the most interesting sections, and perhaps the most extensive turbaries in North-Eastern

Yorkshire, those of Flat Howe and Bluewath. West of Flat Howe and south of the Cock Heads shooting box, the peat is from six to eight feet thick, and exhibits the following succession of deposits :—

Sphagnum Peat	2 feet.
Cotton Grass Peat full of sheaths of *E. angustifolium*	
Birch Zone	2 feet.
Basal Peat, massive	2 feet or more.

The Birch zone is very well-defined, and consists of the Cotton Grass peat full of Birch bark and branches evidently derived from small trees or shrubs. A little to the south, in some sections, this Birch zone disappears, though further downstream the peat has been stripped to the rocky floor on which repose numerous Birch stools, and occasionally remains of Mountain Ash.

Between Cock Heads and Shunner Howe stretches another large moss moor, and from the preceding Flat Howe Peat Holes we pass down stream to the Bluewath Peat Holes on the side of Bluewath Gill above the bridge on the road to Rosedale. The moor slopes down to the gill, and the peat holes extend along the south-west bank of the stream. Tree remains occur here, but not in any defined band, and are usually sporadic. The peat must be twenty feet in depth, if not more.

The moors of the watershed between Bluewath and Urra, though not known as Mosses, so evidently belong to this class, that they cannot be omitted in any account of local moss vegetation. As a whole the plant life of this area consists essentially of Cotton Grass (*Eriophorum vaginatum*) and Heather ; the former being dominant in a few localities, notably on the moor between Loose Howe and Ralph Cross at Rosedale Head (see Fig. 40). This moor is underlain by moderately deep peat (two to three feet), the surface is very wet and dotted with pools, Sphagnum is abundant,

and the Heath Rush is sub-dominant. With the latter are Ling and Pink Bell Heath as associates. Such comparatively pure Cotton Grass moors or Eriophoreta are not wide-spread upon or even characteristic of the Eastern Moorlands. That locally scarce bog plant, the Cranberry (*Oxycoccus palustris*) is stated by Mr. Baker to grow on these moors, but so far I have never met with the species in this locality.* It is restricted to wet peat bogs, trailing over the Bog Moss. It plays a very minor rôle in moor formation.

Near Loose Howe, at 1419 feet, there is a section in peat about six feet thick, lying on a gentle southern slope, without however, the slightest trace of any trees (Fig. 17). A little to the north of the Howe, near Trough House, at Seavy Hill Peat Pits, there is another excellent exposure in the hill peat which presents similar features. On the western side of Danby Rigg, almost in a line with Trough House, similar peat may be observed resting on the hard moorland grits. I have been unable to obtain any evidence as to trunks ever having been found in the peat holes, but we cannot deny that they may exist.

Further westwards, on the northern slope of Stony Ridge, a section about four feet deep was also destitute of tree remains. So far as can be gleaned from the scanty exposures round and upon Stony Ridge, the hill peat here contains no trees.

Between the heads of Baysdale and Bransdale, Cotton Grass and Heather prevail; but the summits of the Cleveland Hills are not characterised by this type of vegetation since the surface is well drained and slopes rapidly southwards.

Omitting the Mosses of the slacks with which we shall deal in Chapter VI., there is no other extensive development of peat bogs in North-Eastern Yorkshire, except on Arden Great Moor, on the summit of the Tabular Range, south of Black Hambleton, where, at an altitude of 1200 feet, a large

* "North Yorkshire."

peaty area is termed the Mosses, an altogether exceptional and singular example in many ways.

In the first place, Arden Great Moor is perceptibly higher in the centre, due, I think, to the form of the rock floor which consists in part of geologically higher beds than the Lower Calcareous Grit; although some of the convexity may be owing to bog formation. In the second place, the moor is not strictly speaking a Moss, whatever it may have been when the name was applied. Heather and Cotton Grass (*E. vaginatum*), in monotonous abundance, are the chief plants; the latter sometimes quite pure and covering considerable areas. Moreover, owing to the dryness of the surface, there is an almost total absence of Sphagnum and other moorland bog plants. In truth, the two species mentioned are the sole occupants of the ground; and a more poverty-stricken moor, so far as variety of plants is concerned, it has rarely been my lot to observe. Generally the flora of the Eastern Moorlands is, when compared with similar regions, singularly poor in species, a remarkable feature to which we shall refer hereafter.

Clear sections in the peat are rare, but the following were measured in gullies—the first towards the western margin, the second towards the centre:—

Sections in the Mosses, Arden Great Moor.

1.

Peat	2-3 feet.
Discontinuous line of white grit pebbles.	
Clayey sand	No traces of pan.

2.

Peat	2-6 feet, variable.
White pebbles of Lower Calcareous Grit.	
Band of thin pan	$\frac{1}{4}$-$\frac{1}{2}$ inch thick.
Clayey soil.	

It will be noticed that these sections differ from those of

other moors, in the presence of a layer of pebbles. Pan, as a rule, does not exist under deep peat in North-Eastern Yorkshire, and the band on Arden Great Moor is very thin and irregular.

We have now described the principal Mosses and their peat beds, and with the facts before us, are in a position to understand their origin. Unfortunately, we are unable to follow the evolution of a Moss in detail owing to the absence of comparative data ; we can only infer it in an imperfect way from scattered observations. Moreover, as before stated, until the peat has been minutely examined layer by layer, we cannot say for certain what has been the actual succession of events in their formation. Still, with the data to hand and with conclusions derived from other districts, we can form a tolerably accurate conception of the history of a Moss.

Their distribution is easily explained ; they cover those areas where the rainfall is highest, where the ground is flat or hollow, and the drainage bad. In the west of Yorkshire, Cotton Grass bogs extend over many square miles on the Pennines where precipitation is high ; higher, even, than on the watershed of Black-a-more. It is noteworthy that the Mosses on Arden Great Moor occur at the western end of the Tabular Hills, where the rainfall is probably more copious than elsewhere along the range. The leaching action of the heavy rains must have dissolved away a large amount of mineral matter from the rocks ; so much so that in places the Mosses overlie the lower Corallian limestones! As a rocky surface poor in plant food is regarded as almost absolutely essential for the development of such moors, we have here one reason for this remarkable feature, since limestones do not, as a rule, support heath vegetation.* The heavy rainfall of the high moors may, therefore, be considered as the primary cause in determining their characteristics and leading to the accumulation of large deposits of acid humus or peat.

* Graebner, op. cit., p. 96.

The Mosses

In describing the origin of the peat or raw humus of fat moors, we pointed out that several causes conspire to produce this substance, the chief being the exclusion of oxygen and the presence of water. What we here have to recognise is that the great peat deposits of the Mosses originate in the same way, but in this case Bog Moss or Sphagnum becomes the principal component. It would take up too much space to describe the peculiarities of these remarkable plants, found everywhere in damp and wet situations upon the moors where the chemical nature of the soil and water is favourable to their development.* It is upon the physical and biological properties of these humble plants, combined with the special climatic and edaphic conditions prevailing on the watershed, that the characteristics of the Mosses depend. Sphagna are peculiarly adapted for living in water; their structure is an admirable contrivance for retaining and absorbing water; they can conduct it rapidly through their tissues, a capacity which can be easily tested by placing their lower ends in coloured water, when, in a few minutes, the plants will be of a similar tint, even to the rosette of short branches at their upper extremities.

Further, the position of a moss moor affords an important clue to its mode of development. So far as the high moors are concerned, we find that May Moss, Yarlsey Moss and Harwood Dale Moss occur in shallow depressions; others, such as that on Arden Great Moor, occur on almost flat land; that at Bluewath is on a gently inclined surface; whilst others, such as those on Stony Ridge and Loose Howe, are on comparatively steep slopes. A characteristic which most of the Mosses present in common is an impervious, or but moderately pervious rock floor, at least wherever this can be examined, as at May Moss, Arden Moor, and elsewhere. It is probably owing to this circumstance

* An excellent account of Bog Moss will be found in Sir Edward Fry's "British Mosses."

that pan is so poorly developed or absent from these moors, for the clayey nature of the soil prevents that percolation of water bearing humic acids which leads to the deposition of this substance. If we suppose these moors to be stripped of their vegetable and peaty covering, as they must have been at some period in their history, the heavy rainfall would produce a water-logged condition of the surface; and, though we cannot be certain, it appears not unlikely that at Harwood Dale, May Moss, and Yarlsey Moss, the depressions were perhaps originally the site of large pools or even of small lakes.

Confining our attention to the three Mosses in question, we have a key to their mode of development in the vegetation of old peat holes, such as those on Blakey Ridge, between Thorgill and Rosedale Bank Top, where the flat surface of a Heather and Cotton Grass moor (*E. vaginatum*) is covered with a layer of peat about four or five feet thick, which has been excavated in a series of shallow cuttings since abandoned. In all the hollows water has collected; some present an undisturbed sheet; others have thin films of green algae and Bog Mosses floating in them. At a more advanced stage we find Sphagnum covering the water; whilst some pools are choked up with plants from the bottom to the surface. In these we notice the occasional growth of Rushes, and more frequently *Eriophorum angustifolium*. The final stage in the infilling of old turbaries is represented by the appearance of *E. vaginatum* in abundance together with sporadic clumps of Heather. Fig. 19 represents an old peat digging, near St. Helena House in Danby Dale; here we see the Cotton Grass (*E. angustifolium*) flourishing with Rushes in water before much Sphagnum has appeared.

In some districts, particularly lowland moors, the first stage in the formation of a Moss is the luxuriant growth of a "fen" vegetation which consists of Reeds (*Phragmites communis*), Prickly Cladium (*Cladium mariscum*), Lake

Photo by] FIG. 20.—MOLINIETUM OR FLYING BENT MOOR. [*Frank Elgee.*
CASTLETON IN BACKGROUND.

Photo by] FIG. 21.—THE MOORS FROM LASTINGHAM. [*Godfrey Bingley.*

Scirpus (*Scirpus lacustris*), and other species.* Fen plants, though growing in wet places, are very distinct from those of moorland bogs, principally owing to the character of the water in which they live, this being relatively richer in mineral salts, and of subterranean origin. A poor siliceous soil may support a fen association for a time, when the mineral content is somewhat richer owing to the presence of numerous springs, but the gradual exhaustion of the soil by percolating rain water and the growth of peat cause this type of vegetation to disappear, and moorland bog plants, Cotton Grass, Sphagnum, etc., appear on the scene. As yet we have no evidence that this stage has ever existed on the high moors, though it seems to have been the case with some of the Mosses of the slacks (see Chapter VI.). There is no reason why this type should not have been an early stage in the formation of the higher Mosses, for on the upland moors of the Pennines the Common Reed has been detected in the peat deposits,† and I have myself found the same plant growing with Cotton Grass in a peaty pool on Danby Low Moor. A thorough study of the local peat will alone settle this interesting problem.

Supposing the early stages of Harwood Dale, May Moss, and Yarlsey Moss not to have been marked by a fen vegetation, then the sequence of events in their history may have been somewhat as follows:—Bog Moss would first appear in the water, probably round the margins, or, as must often be the case, floating on the surface in the centre of the pools. In time the Sphagna would cover the whole surface with a floating bright green carpet of some considerable thickness, a stage known as the Sphagnetum and very typical of the bogs of Ireland, though seen only sporadically in small ponds on the Eastern Moorlands to-day. The plants sink to the bottom when they die, and there accumulate; and, being sheltered from the action of the atmos-

* "Types of British Vegetation," p. 257.
† Op. cit., p. 270.

phere, they form those immense beds of peat so characteristic of Mosses. All the other causes which contribute to the formation of acid humus are actively, nay more actively at work in a Sphagnum bog than on fat moors. Bacteria, worms and grubs are practically absent ; the thick growth of the Mosses on the surface of the water prevents access of oxygen ; and the humic acids resulting from the reduction of the plant remains are of a highly preservative and antiseptic nature. If we poke a stick into one of these morasses, bubbles of marsh gas and sulphuretted hydrogen are liberated, and sometimes on hot summer days, after rain, such a bog has a powerful odour owing to the escape of these gases. If they ignite, Will-o'-the-Wisps dance over the surface ; but, so far, I have never observed any on the Eastern Moorlands, nor even heard of their having been seen, though there is no reason why they should not be present.

The pools finally become filled with thick peat upon whose wet surface, Sphagnum, though abundant, will be interspersed with other ericetal plants. What these later species will be depends upon a variety of factors. If the water is not too acid, and still contains some mineral matter derived from the subjacent rocks, Rushes (*Juncus conglomeratus* and *effusus*) may be the first to colonise the swamp, as at Yarlsey Moss, and in hundreds of small swamps all over the moors. That these plants actually need a richer food seems probable when we observe their luxuriant growth in bogs caused by springs, in the waters of which larger quantities of dissolved mineral salts must of necessity be present. More frequently on the typical Moss, Cotton Grass (*Eriophorum angustifolium*) is the first species to grow in the pools that rest upon the deep peat (see Fig. 19). When these have become filled up, *E. angustifolium* is superseded by its ally, *E. vaginatum*, which prefers less damp situations. With this last species comes the Pink Bell Heath and to a less extent the Heather, as well as the rarer bog plants, Sundew, Bog Asphodel, Cranberry, etc.

It is possible that the convexity of the surface first arises during the Sphagnetum stage of a Moss developing in water, for when the layer of Bog Moss has attained a sufficient consistency, every shower of rain not only increases the volume of water retained by the plants, but some passing through, adds to the volume of water beneath. Consequently, the centre of the bog being the point of least resistance, yields more readily than the circumference (where the mosses are thicker and the water is shallower) to the pressure of the underlying liquid, and becomes more or less elevated above the original level of the pool. In Ireland, continual heavy rains have been known so to augment the pressure and the amount of water retained by the Sphagnum, that the huge raft of vegetation bursts and the contents of the bog are destructively precipitated over adjacent tracts of country.

Since the above explanation occurred to me, I have studied the causes assigned to this phenomenon by other workers in this department of science. Sir Edward Fry attributes the convexity solely to the power that Sphagnum has of being able to hold up large bodies of water against gravitation. Irish bogs, for instance, are sometimes so high in the middle " that they reach the height of the church-steeples of the adjoining country without any rising ground intervening."* Why this lifting capacity should act more effectively in the centre than at the edges is not clear unless it is that at this place there is more liquid to absorb. Bog Mosses undoubtedly retain large quantities of water on the slopes of mountains, hills and moors ; but it is not at all clear how this is going to elevate a bog in the centre. If we examine the Mosses and bogs on the Eastern Moorlands, we invariably find that those occurring in sloping hollows near springs, those on slopes and flats such as Bluewath Loose Howe, etc., and particularly those that occur in slacks, are very little higher in the centre than at the edges ; and if

* " British Mosses," p. 55.

we ask what feature these bogs have in common and in what way they differ from those which are convex, we find it to be in the fact that there always is and always must have been an escape for superfluous water. Whereas in the case of May Moss and Harwood Dale Moss, though lateral escapes now exist for the superfluous drainage, a careful consideration of the ground has led me to the conclusion that during the earlier stages of their history such escapes either did not exist or were sporadic. It is clear that where the effluent drainage is equal to or greater than the inflow there can be no convexity of surface. Two old peat bogs—the Gale Field near Goathland Church, and the Kildale Carrs, presently to be described—are both higher in the centre ; yet there is no apparent drainage out of them.

Continental investigators ascribe the convexity to the centrifugal growth of Sphagnum itself.* Where Sphagnum bosses growing alone are observed, they almost invariably possess a convex shape, resembling a bowl turned upside down. I have observed them round Bracken stems, with Crowberry and Bent Grass (*Agrostis canina*) growing on or through them. From this it is easy to see that the continual growth of the mosses around the periphery will produce, in time, a bog of the same form. From this view, a moss moor is merely a gigantic boss of Sphagnum. The probability is that the three causes indicated have all contributed to produce the singular convexity of some Mosses. If the Sphagna first flourished in water in the manner described above, then, after the surface had become a sheet of vegetation, the pressure of the underlying liquid, the lifting power of the plants, and their peculiar manner of growth, would all co-operate to elevate the centre of the bog. If the moss moors originated on the bare ground or in water-logged hollows scattered here and there over the uneven surface of the soil, then the third factor, and to a less extent the second, would cause the elevation.

* Schröter and Früh, " Die Moore der Schweiz," p. 78.

The Mosses

By the time a Moss has become clothed with Cotton Grass and Heather the peat has attained a considerable thickness and is solid throughout. Having absorbed all the water of the original site, the Sphagna become more and more consolidated, and the general wetness of the surface is maintained by the heavy rains of the hills and the super-saturation of the raw humus. Were evaporation from the Moss to exceed the supply of water from all sources, aerial or telluric, the bog would slowly dry and ultimately possess a very different plant community, probably including trees. Some of the shallower moss moors may, in the past, have thus covered a wider area, but have been converted into Heather moors through the somewhat suicidal action of Sphagnum, which, absorbing all the surface water, and not being replenished by a sufficiency of rain, has had to yield to the dominating Heather. That this has been the mode of origin of many fat moors encircling the Mosses of the watershed cannot, I think, be doubted, when we reflect on the thickness of the raw humus on which they occur, and the hummocky and irregular surface that ensues.

In the lower valleys there are two peat beds which have progressed towards a dry stage. Such is the Gale Field, near Goathland Church. Higher in the centre than at the circumference, the Gale Field has arisen in the way indicated; but its surface is now almost dry with much grass, occasional tufts of Cotton Sedge, and sporadic Sweet Gale, the latter plant being rarely seen on the higher Mosses. More remarkable from a botanical standpoint, though much damper than the preceding, is the great peat carr dividing the drainage of the Leven from that of the Esk, at the upper end of Kildale. Here the convex surface of the peat supports a very distinct plant association somewhat resembling the vegetation on Hutton Mulgrave Moor, described in the last chapter. The most abundant species are the Mat Grass (*Nardus stricta*) and the Tufted Club Rush (*Scirpus cæspitosa*), with a sporadic diffusion of Cotton Grass (*Erio-*

phorum angustifolium). Intermingled with these are beds of *Carex glauca*, an abundance of Tormentil (*Potentilla tormentilla*), and scanty patches of ill-grown Bilberry and Ling. In winter a fine carpet of lichens of the genus *Cladonia*, principally Reindeer Moss, is a conspicuous element amongst the Sphagnum plants which still play a large part in the botany of this unique piece of moorland. Towards the margins the peat is much drier and supports grasses, such as *Nardus*, *Agrostis*, *Molinia*, *Aira flexuosa*, and *Anthoxanthum odoratum*. At the eastern end, in some old peat cuttings, there is a rich growth of *Eriophorum angustifolium* and the Pink Bell Heath with the Common Tormentil in the wettest places. This typical bog vegetation is in marked contrast to the drier grass land on the summit of the cuttings! Here and there Gorse bushes occur, even towards the highest part of the peat carr, and formerly Birch and Mountain Ash also grew on the peat, for not only do their remains occur in it but an occasional tree still flourishes near the north-western corner. That trees were once numerous may be inferred from the old name, peat carr, the latter word being usually applied to swampy land overgrown with brushwood. This would indicate that at one time the ground may have been even drier than it is at present; but that the carr is slowly drying up again is testified by the surrounding ring of grass vegetation with Gorse that is slowly advancing towards the centre. I would ascribe the comparative dryness of these two peat moors to the excess of evaporation over the rainfall, which is much less in the valleys than on the watershed. Moreover, there does not appear to be any escape for their water which, owing to the position of both, is largely atmospheric.

The development of moss moors on flat land and slopes has followed a similar course, but here the original conditions have probably been different. If we take the one at Bluewath Beck, we find the peat resting upon thick clay, and from this we must conclude that formerly the surface was water-

logged and peat formed in the usual way. But another factor has undoubtedly come into play, and that is the growth of the bog down the slope, a process which seems to have occurred during the early history of the moor. To understand how thick peat deposits could have arisen on these slopes is puzzling, for when the underlying soil was destitute of vegetation the rain would readily drain away, whilst some of it would percolate through less impervious strata. But the difficulty disappears when it is remembered that no slope is perfectly regular, that some of the rocks are impervious, and consequently pools of water would collect in hollows and become filled with Sphagnum, which could hold up larger and larger volumes of water as it spread. At the same time the growth of peat on the summits of such ridges as Loose Howe and Stony Ridge would gradually enable the Bog Mosses to extend down the slopes and join those growing in the hollows. Other slopes, such as that at Cock Heads, owing to the porosity of the strata rising above the peat moor, do not possess a very mossy vegetation ; but, although the peat is somewhat thick, it supports Bilberry and Ling. It is possible that the presence of Bilberry is also partly due to the great elevation and to the exposed situation of this area of the moors. In the West Riding, Drs. Smith and Moss record what they term a Bilberry summit where on the highest ridges of the Pennines, Bilberry is the sole plant. Altitude is not, however, the chief factor in determing its existence ; the essential feature is that it is exposed to all conditions of weather.* These Bilberry summits rise above the moss moors dominated by Cotton Grass, and the occurrence of the Bilberry on the Cock Heads ridge may be an approach to this type of vegetation.

Once the surface of a slope becomes covered with Bog Moss, the peat gradually increases in thickness. In all

* " Geographical Distribution of Vegetation in Yorkshire, Leeds and Halifax District," pp. 12-13.

instances where it exists at valley heads it has probably originated in the way described. During the development of the sloping moss moors, dwarf trees or scrub has occasionally grown upon them. In this respect the Bluewath Peat is unique, for the section clearly shows that the Moss first formed on the bare ground until a considerable depth of peat accumulated. Then Birch scrub flourished upon it ; though whether this was due to a drier climate supervening for a few years, thus making the surface more suitable for the growth of such shrubs, cannot at present be decided. It appears to have been a very local phase since other sections in the same locality only reveal the presence of occasional trees, some of which are to be observed with their roots in the underlying rock. If the downward growth of such moss moors has actually taken place, the bogs would encroach on the wooded higher reaches of the gills falling into the dales. For where hill peat is traced downstream until it becomes valley peat, this latter almost invariably contains the remains of trees. Thus at Pike Hill Moss, the hill peat passes into valley peat at the head of Collier Gill, a stream rising in the Moss and flowing into Wheeldale Gill. Here, at an elevation of 1000 feet, the thick peat is full of the bark and trunks of small Birches ; but on the flat morass, only seventy feet higher, no traces of the plant can be found (Fig. 18). The trees have evidently been engulfed by the downward growth of the bog, and thus the site of an upland wood has been converted into fat moor.

It is not improbable that many of the Cotton Grass and Heather moors of the watershed have developed on the bare ground, but as to the actual stages in their formation we have no evidence. The process, as it occurs in North Germany, has been described by Graebner (op. cit. p. 94), but it may have been quite different here. Three stages are indicated by Graebner—a preliminary stage when algae colonise the damp surface and form a thin humus ; then,

numerous damp-loving moor plants settle upon the humus, *Molinia*, Heath Rush, Sundews, Pink Bell Heath, Cranberry, etc.; next Bog Mosses begin to flourish among the higher plants, the separate cushions of moss unite and form a continuous layer. Peat afterwards begins to accumulate; many of the earlier plants disappear; and the moss plants, Cotton Grass, Club Rush, Sweet Gale become dominant. In some such way as this, the Mosses of Arden Great Moor must have arisen; but for reasons which are as yet unknown, they have become much drier and support Heather and Cotton Grass only, Bog Moss and other typical wet moorland plants being rare or quite absent.

To ascertain the age of the hill peat is by no means easy, for this substance varies very considerably in its rate of formation. Since the deepest layers began to form, thousands of years or only a few centuries may have elapsed. If the lower layers could be shown to contain the remains of Arctic plants then the peat would date back to the close of the Ice Age, but until this has been determined we have no clue as to the antiquity of the deposits except by vaguely asserting they are post-glacial. May Moss, as stated in the introduction, was known as such in the reign of Henry I., which makes it at least seven hundred years old.

Although we do not yet know the exact age of the great peat beds of the high moors, and so cannot say how long they have taken to form, the question arises as to whether the process of peat accumulation goes on indefinitely. If the rainfall continues as high on the watershed as it is now, and if Sphagnum continues to flourish as at present, there would appear to be no limit to the thickness which the raw humus may attain, and yet it apparently remains constant. The same question arises, too, with regard to the humus of both the fat and the thin moors, which year after year also remains more or less constant. This is due to the rate of erosion to which all deposits, whether organic or inorganic are subjected by the action of the atmosphere.

If solid rocks can be carved into picturesque hills and valleys in the course of ages, softer organic deposits such as peat must be even more easily destroyed by atmospheric agencies.

Water carrying humic acids, either percolates through the Mosses or filters in from the surrounding slopes, and ultimately reaches the soil or rock below the peat. Although it is stated that the lower layers of a peat bog are impervious, nevertheless, if we examine a section such as is furnished by the small stream, Bluewath Gill, of the peat resting on the soil, we shall find that water is continually trickling from between the humus and the soil. This clearly points to some amount of water circulation at the junction of the two, and if the floor is sloping, the water drains away to the borders of the Moss, and a small amount of underground erosion, partly chemical and partly mechanical, must take place. Repeated year after year, the erosion thus set up will remove an appreciable amount of peaty matter. Owing to the physical structure of Sphagnum being still retained in the peat after the death of the plants, the Mosses become large reservoirs, and usually have small streams draining out of them. These rivulets bear away in flood times large quantities of peaty detritus derived both from the surface and the bottom of the Mosses. Bluewath Beck shows this distinctly where the stream has cut deep into the moor. Here huge blocks of peat have fallen into the stream ; there the waters have excavated great hollows in the banks which are overhung by ledges of peat held together by the roots of plants. In other places the Ling bordering the stream is covered with mud, sand, and peat deposited by the last flood. Where Eller Beck issues out of May Moss, it forms a waterfall four or five feet high over a ledge of peat which is slowly being eroded back. This effluent drainage, however, does not exceed the supply or otherwise the Mosses would disappear, and as they are always wet, it is clear that the outflow does not exceed the rainfall ; though even if this were the case, the water-

retaining powers of the peat may prevent its becoming absolutely dry unless a less humid climate were to supervene.

Erosion must cause a Moss continually to diminish in mass, and though it would perhaps not be strictly correct to say that it is continually sinking to its bed, yet this is not at all unlikely, if the underground erosion is perpetual. The probability is that the plants on the surface compensate for this loss, and so maintain the peat at a comparatively constant thickness, if not causing its increase. Erosion, however, is not so active upon the Cleveland peat moors as in other parts of the country, and it is rarely that the surface is excavated into " hags," or detached masses of peat. On the Pennines this process of peat destruction is active in some places, and leads to the replacement of Cotton Grass by Bilberry, which, in its turn, is often replaced by Mat Grass and the Wavy Hair Grass, but, so far as I am aware, this has never occurred on the Eastern Moorlands.*

It should also be remembered that the ericetal plants utilise substances in the peat, and this must entail a further slight loss, a process in operation all over the moors, but to a partial extent, the material thus absorbed is returned to the humus when the plants die. On the fat and thin moors, burning and turf graving have seriously interfered with the normal growth of raw humus, and on all the action of running water must remove a large quantity of plant remains, as may be witnessed on bare spaces after heavy rains, when fragments of stems, leaves, sand grains, and detached pieces of humus are washed down slopes and form little parallel waves of debris undulating along the hill sides. In hot and dry summers, such as that of 1911, the humus becomes very dry and crumbly, is blown about by the wind, and rises in small clouds. This process, also, when repeated, even at long and irregular intervals, causes a decrease in the amount of humus

* " Types of British Vegetation," p. 281.

which has to be replaced by a further accumulation during more favourable periods.

Here our account of the Mosses must close, though we have not been able to treat of them fully. Much more research is needed before their history can be fully written, but what has been ascertained enables us to form a conception of their origin. We may sum up the different kinds in the following table :—

Sphagnum bog or Sphagnetum. Rare on the eastern moors.
Rush and Sphagnum bog, or Juncetum. Yarlsey Moss.
Tetralix moor. May Moss.
Cotton Grass moors, or *Eriophoreta vaginati*. Rosedale Head.
Cotton Grass and Heather moor. Harwood Dale Moss, Pike Hill Moss, Arden Great Moor—almost universal on the watershed.
Tufted Club Rush and Mat Grass moor on deep peat, or Scirpetum. Kildale Carr.
Sweet Gale, Cotton Grass, and Grass moor on deep peat. Gale Field, Goathland.

The Mosses are perhaps the most interesting of all moors, both botanically and physically. Their existence primarily depends upon a poor siliceous soil more or less impervious, a copious rainfall, and those wonderful flowerless plants, the Sphagnaceæ or peat mosses. To realise the great influence heavy rains exert upon the high moors, they should be visited in winter. Places so pleasant and green in summer become impassable swamps ; grassy sheep walks are converted into shallow, spongy bogs ; and sandy roads and cart tracks have streams of water flowing in the wheel ruts. Throughout the winter this state of affairs prevails, and even as late as the end of April in 1908, the moors were covered with thin, slushy snow, re-saturating the already saturated vegetation. But for these climatic conditions, the Moss and the Heather moor would cease to be, for as the reader must have clearly seen, an abundant supply of moisture is essential to their existence ; it is this which gives rise to the great peat beds, and therefore, to this all important factor some of the most impressive aspects of plant life are due.

CHAPTER V.

MOORLAND SLOPES.

HITHERTO the nature of moors on comparatively flat elevated land has alone been considered, but owing to the manner in which the *massif* of North-Eastern Yorkshire is broken by the great dales and their small gills, steep slopes form a characteristic feature in the topography of the district. They are clothed with types of vegetation which diverge considerably from those we have just described, and yet we meet with connecting links on every hand, and transitions to other plant associations which show conclusively that the slopes were formerly the site of woods and forests.

Except on the bold escarpments of the Cleveland, Hambleton and Tabular Hills, the slopes always form the sides of the great dales and their tributaries, often rising to a height of three hundred or four hundred feet from the bottom of the valleys. They vary much in altitude, steepness, contour and direction, all of which exert an influence on the vegetation, and upon the amount of cultivated land they bear. In some dales, the "sides" are reclaimed almost to the moor edge; in others, fields extend about half-way up; whilst in the gills or head waters of the dales which rise high on the moorlands, the vegetation is practically undisturbed, and in its natural state. Moreover, the conditions of plant life are complicated by the outcrop of beds of shale, sandstone and limestone, which run along the slopes, one stratum above another, and which produce different kinds of soil on weathering. Again, runnels of water from springs and the downwash of rain cause considerable erosion even on gentle inclinations, and the accumulation of fine detritus at lower levels forms a more varied

soil than that of the higher moors. Thick peat rarely accumulates except in hollows caused by springs, and in many localities the vegetable humus is extremely thin.

Consequently, regarded as a whole, the conditions of plant life on the slopes are favourable to a more varied and luxuriant vegetation than that of the peaty moors, a vegetation which ranges from heather-clad land, through intermediate types, to woods of Oak and Birch. Genuine peat plants do not always find suitable stations on the steeper sides, and are therefore somewhat rare or disappear altogether. Everywhere, however, a struggle is taking place between the moorland plants properly so-called, and the slope plants, usually to the disadvantage of the former.

As mentioned in the chapter on the thin moors, the grassy type sometimes occurs on gentle and even on steep slopes, but the characteristic species is undoubtedly the Bracken (*Pteris aquilina*), one of the few ferns which competes in a successful manner with flowering plants, at any rate in England. It is *the* plant of the slopes ; in the larger valleys frequently extending unbrokenly for miles, and undoubtedly forming, after the Heather, the most salient plant association of North-Eastern Yorkshire. All the botanical aspects of the moors are impressive, but perhaps these forests of Bracken are more so than any other. They suggest, and are possibly survivals of, that far distant time when ferns and flowerless plants generally were dominant over the whole earth.

The fern rarely flourishes on the peatier moors, though where this does happen, it usually becomes stunted. Several reasons may be assigned for its absence from such moors. First, pan prevents its strong and deeply penetrating roots from reaching the rock soil ; second, the wind is too powerful ; and third, it is not strictly speaking, a true moorland species, but a plant which is especially characteristic of open woods of Oak, Birch or Pine on sandy soils. Where peat or raw humus is of some thickness, the Bracken is

rarely or never observed. Hence it attains its most luxuriant development on the sheltered and frequently sandy slopes of the hills, gills and dales.

In some cases where very closely grown and somewhat rank, scarcely any other plants are associated with it: a few grasses, a little Bilberry and Hair Moss, alone maintain a precarious existence beneath its too protecting shade. A more open growth enables the Brown Bent (*Agrostis canina*) and the Sheep's Fescue Grass (*Festuca ovina*) to form a green sward beneath the fronds, and Gorse bushes are not uncommon. As the Bracken does not fully expand its fronds until late June, the grasses can vegetate, but later on they are completely shaded by the thick foliage of the fronds.*

A most frequent type of slope vegetation is that in which Ling and Bracken are almost equally abundant; that is to say, bosses of Ling are irregularly interspersed amongst the ferns. Other species are characteristic of this association, moorland grasses for instance, and more particularly the Bilberry or its ally, the Cowberry (*Vaccinium vitis-idæa*), an association well-developed on the northern side of Baysdale (the left-hand slope in Fig. 52). Here the latter species occupies a most prominent rôle in the vegetation, and nowhere else in North-Eastern Yorkshire have I seen this beautiful moorland plant so abundant as in the lower reaches of this dale. With its slightly inrolled, glaucous leaves, white flowers and scarlet berries, it plays the same part on this slope that the Bilberry does on others. The Cowberry is of sporadic occurrence on most moorland sides where the soil is somewhat peaty, and it rarely becomes dominant.

In Fig. 51, which represents the uppermost reaches of Winter Gill, a branch of Glaisdale, a further peculiarity of slope vegetation is clearly shown. Here we find that

* "Types of British Vegetation," p. 143.

the Bracken and Heather are not mixed, but occur in definite strips and patches, light-coloured in the former, dark in the latter. Everywhere a keen struggle for supremacy takes place between the two species on the slopes, and where they adjoin the lines are often of almost geometrical regularity. This is not wholly natural, being partially due to burning which, on slopes, has in many localities, the effect of encouraging the fern at the expense of the Heather. The deeply-striking roots and quicker growth of the Bracken enable it to spread on to the swiddens before Ling has really a chance to appear; and we may often observe recently-burnt areas in June, with the delicate green shoots unfolding above the blackened ashes and stems of the former vegetation. As the firing is usually restricted to fairly regular and definite areas, the resulting masses of fern are of similar patterns. In the view of Ewe Crag Slack (Fig. 23), the illuminated slope is seen to be quite bare and stony, the result of burning in the spring of 1909. Two years afterwards, this slope was thickly overgrown with Bracken; and it is not improbable that in some localities, many heather clad slopes with a little Bracken here and there have been converted into rank forests of fern by burning. Near Castleton, a swidden on the slope of Baysdale was observed, on which the principal species were the Purple Moor Grass (*Molinia cærulea*) and the Tufted Club Rush (*Scirpus cæspitosa*), a most unusual type of vegetation to appear on a burnt moor especially when surrounded by Bracken and Heather. In all likelihood, the plants were on the spot before the place was fired, and the somewhat damp situation has given them an opportunity to spread (see Fig. 20).

On the northern slope of Eskdale, between Commondale and Danby End, the Ling dispersed amidst the Bracken is almost wholly of the form known as *incana*, a downy or pubescent variety whose grey clusters have a mildewed appearance in striking contrast to the usual tints of the plant. The reasons for this remarkable dominance of

downy Ling are not at all clear. The slope does not appear to differ from others to any marked extent, except perhaps in its somewhat sandier soil. It is to be noted, however, that this side of Eskdale is the only considerable slope which faces south in North-Eastern Yorkshire, and consequently is much exposed to the sun. Hairy or downy coverings on leaves are often safeguards against excessive loss of water by transpiration, a function which we saw in Chapter II. is largely regulated by the inrolled leaf of the Heather. In this case it seems not unlikely that extra protection is required owing to the drier soil and the full exposure to the sun's rays, which would otherwise cause an injurious loss of water.

Traced upstream in shallow valleys, the Bracken becomes rarer and rarer on the slopes, and is ultimately confined to small patches close to the streams. This decrease in abundance is no doubt largely due to an increase in the thickness of the raw-humus which can form to some depth on slight inclinations. More interesting, however, is the appearance of trees and shrubs in the vegetation of most of the normal Bracken slopes. Thus, on the northern side of Lonsdale, Bracken and Ling are dominant, but here and there solitary Hawthorn trees occur ; and in the view of Baysdale (Fig. 52), trees can be seen on the slopes, the principal species being Mountain Ash, Juniper, Hawthorns, Oak and Scots Pine. It is in this delightful valley that the Juniper is perhaps more numerous than elsewhere in the district ; in the lower parts it is usually met with near the stream, but higher up the dale on the western side, there is quite a scrub of these plants. Fig. 27 represents a group of Juniper and Hollies (the central trees) growing near the stream with bracken-clad slopes behind.

In many places a fairly thick scrub is developed, well shown in Newton Dale in Fig. 1, where the right-hand slope is studded with shrubby forms of Birch, Oak, Rowan, and Hawthorn, the first two species being most numerous and

characteristic. In other localities Bracken flourishes in woods; under the shade of the Birch as at Commondale; under Pines and Larches, as on the Eston Hills; and under Oak and Birch as in numerous wooded gills to be hereafter described (see Chapter VI.). These facts all tend to show that wherever the ferns occur on the hillsides, they mark the site of former woods or forests, a stage in the botanical history of the moors which we shall discuss at the end of the next chapter. It will suffice here to remark that in many parts of England, especially in lowland Oak woods, the Bracken is quite a dominant plant of the undergrowth, and I have seen such woods on the sandy soils of Warwickshire.

That the Bracken grows best on slopes in this district is proved by its distribution on the escarpment of the Tabular Hills, especially at their western end and in Newton Dale. The eastern slope of the great hill of Black Hambleton (Fig. 46), is partly overgrown with a thick scrub of dwarf Birch and Oak. But a more interesting fact, and one showing how the fern is more dependent on topography than on altitude, is shown where the regular slope of the escarpment is interrupted by a projecting ledge or plateau, caused by the outcrop of a hard stratum, the Kellaways Rock. Very little fern flourishes upon this flat, though it exists in full vigour on the slopes above and below. On the ledge Ling regains its sway. This double Bracken slope, as we may term it, extends for some distance eastwards along the escarpment until the Kellaways Rock ceases to form a ledge or scarp. In Newton Dale between Levisham Station and Saltersgate, the same rock forms a wider plateau at the foot of the escarpment, and on the very brink of the great valley itself. The steep slope rising from the railway to the edge of the plateau and the plateau itself are shown in Fig. 31, and in the frontispiece; the slope is clothed with Bracken and an Oak and Birch scrub, whereas the plateau is chiefly covered with Heath Rush, grasses and occasional spreads of Heather, above which ascends the bracken-clad

escarpment of the Tabular Hills. Of course, the fern does grow on the ledge, but it is subordinate, nor is this comparative rarity due to the flatness, for Bracken as we have just stated exists abundantly on levels in lowland Oak woods. To what, then, is this peculiar distribution due ? Probably to the circumstance that on the plateau the raw humus is too deep and too acid, for the range of Bracken on the Eastern Moorlands clearly indicates the likes and dislikes of the plant. It prefers slopes of all elevations ; it prefers sandy and siliceous soils ; it grows well under the trees of fairly open Oak, Birch and Pine woods ; it avoids damp and wet situations, and is never seen on Sphagnum, Cotton Grass or Juncus swamps ; it cannot tolerate too much acid peat ; and it does not pass far into the pure Heather moors.

The double Bracken slope of the Tabular Hills naturally leads us to a consideration of the zonal arrangement of plants according to the elevation or according to the character of the underlying rock soil. The altitude of the Eastern Moorlands does not appreciably influence the species we are here considering ; the principal factor in determining plant zones on the slopes are the soils, not only those derived from the different strata, but also those formed at the foot by downwash. So many conflicting combinations of soil occur that it is only here and there that we have distinct lines of vegetation running along the hill-sides. The most striking instance occurs on Dalby Warren, and was first pointed out by the late Mr. Fox-Strangways.* In many ways Dalby Warren is a remarkable moor, and merits more attention than I have so far been able to devote to it. A glance at the moorland map shows that the warren, lying east of Pickering, is the greatest spread of heath vegetation south of the general boundary of the moors, and it occurs on the summit of the Tabular Hills. The warren is deeply divided by no fewer than six small branch valleys

* " Jurassic Rocks of Yorkshire," p. 482.

falling into Thornton Dale, and it is along the slopes of these tributary dales that the phenomenon referred to is displayed. Here a thin band of limestone is intercalated between two sandstones, one of which forms the floor and lower slopes of the branch dales, and the other of which forms the upper slopes and summits of the ridges separating one valley from another. "The calcareous soil of the limestone," says Mr. Fox-Strangways, "is covered by grass or Bracken, while the arenaceous soil of the latter is always clothed with Heather. The junction between the two is so sharp, and the contrast of colour between the green herbage and the brown moorland so striking, that the divisions of the strata which run in parallel bands along the hillsides, can be followed by the eye at some distance." In Sand Dale, the northward-facing slope has a central band of Bracken with Ling above and below, and similar features are shown in Heck Dale.

The deep branch valleys of Ryedale rising in Arden Great Moor resemble those on Dalby Warren; here there is a decided tendency for Heather to cling to the outcrop of the Lower Calcareous Grit which forms the central stratum on the slopes, with Bracken dominant above and below. Elsewhere on the Tabular Hills where the same grit runs along the valley sides, strips of heath vegetation may be observed, such as those indicated on the map, south of the village of Newton-on-Rawcliffe.

A fairly well-marked zonal arrangement of plants may be observed on the slopes of the Cleveland Hills, and in some of the larger dales. Below the Heather moor of the summit level comes a band of Bilberry, followed at lower levels by a broad zone of Bracken; whilst the lowest slopes, where unreclaimed, are usually characterised by masses of Gorse with grassy interspaces. Sometimes a belt of wet land clothed with Rushes occurs below the Gorse zone, where the slope has a flat expanse at its foot. Between West House, Kildale, and Commondale village, the northern side of the

valley through which the Whitby railway runs is covered with a broken scrub of Oak, Birch, Rowan and Thorn, passing below into a well-defined zone of Gorse with a great spread of Rushes on a flat at the base. Even where the slope has been enclosed and cultivated, Bracken, Gorse and Rushes re-appear in the pastures, stragglers emerging at corresponding levels.

There is a marked preponderance of Bilberry on the uppermost parts of slopes just below the moor edge, and above the Bracken zone. In fact, the Bilberry is, next to the fern, one of the most characteristic plants of the dale sides, flourishing in stony situations that are exposed to the weather. In May and early June, the abundance of Bilberry becomes very conspicuous, for the brilliant emerald green of the new foliage colours the slopes for miles, and it stands out in vivid contrast to the dead brown Bracken below, and the dark Heather above, as may be seen in Bilsdale, Westerdale, and Danby Dale. On the steep and rocky escarpment of the Cleveland Hills which are exposed to cold north winds, the plant is very numerous. The northern face of Kirby Bank has a quantity near the summit, passing down into Bracken ; on the same face of the great outlier of Cranimoor, the precipitous summit has long strips of dark Ling spreading like feelers into the lower and greener Bracken and Bilberry zones. The western side of Cold Moor towards the south is also thickly clothed with Bilberry.

At Danby Crag, which forms the rocky and precipitous end of the wedge of land separating the two Fryup Dales, Bilberry is once more the chief species on the almost precipitous slopes near the summit, and as illustrating how varied the vegetation of such a locality may be, it is instructive to note some of the plants growing amidst the Bilberry. Sheep's Fescue Grass forms the turf with occasional specimens of the Sweet Scented Vernal Grass (*Anthoxanthum odoratum*). The Heather is very small, whilst familiar

species, certainly not ordinarily found on moors, are the Anemone, Primrose, Wood Sage, Wood Sorrel and Dog Violet. These species are the relics of wood undergrowth which formerly extended to the top of the hill, as indeed is now the case on most parts of the crag, but the destruction of the trees either by natural or by artificial means, has let in the hardier moorland plants which have not yet been able to oust the purely woodland species. The chief tree in the Danby Crag woods is the Holly, which here attains a larger size, and is more gregarious than in any other part of the district. The Holly is not rare on many slopes, and in the present instance appears to form a natural wood. Towards the summit of the ridge Birch becomes, as usual, a characteristic feature.

One further example of the preponderance of Bilberry towards the moor edge and above the main Bracken area may be noticed. The westerly slope of Westerdale, beyond the Baysdale Road, is chiefly clothed with this species, broken by patches of Ling ; Bracken is not abundant, but becomes more so towards the drystone wall separating the cultivated from the uncultivated land lower down the slope. Fescue Grass forms a luxuriant undergrowth, and the Hard Fern (*Blechnum spicant*) is not infrequent.

In a few localities Bilberry dominates the whole slope, and then we have a Bilberry moor developed. The western side of Little Fryup Dale furnishes one of the best instances ; and so well-known to the dales' people is this moor, that " bilberrying " on an extensive scale takes place in August. The plant dominates the slope from the dale road to the highest point of Danby Ridge, forming a short shrubby turf, cushioned with masses of Reindeer Lichens and mosses (chiefly *Dicranum scoparium*). Heather, in long strips, is abundant towards the summit, and also a little way down the slope where it becomes mixed with the Bilberry. Bracken occurs frequently throughout the association ; Crowberry is not uncommon ; whilst other characteristic species are

the somewhat rare Chickweed Winter Green (*Trientalis europæa*, also found on the most elevated peat moors), the pretty white star-flowered Heath Bedstraw (*Galium saxatile*), the Cow-wheat (*Melampyrum pratense* var. *montanum*), and the usual moor grasses.

This slope faces east, and there can be no doubt that the position has some share in determining the nature of the vegetation, as the Bilberry can bear exposure to the most bitter winds, a fact illustrated by its abundance on the high ridge of Cock Heads, referred to in the chapter on the Mosses, and on slopes facing north. Two remarkable illustrations of the dominance of Bilberry on northern slopes are known to me. The first is in the valley of Eller Beck. Where this small stream issues out of May Moss, it flows through a narrow channel with sides clothed principally with Bracken ; but on the northward-facing side of a smaller tributary stream, Bilberry replaces the fern, and where the two streams join, the two plants mingle on the angle of the slope. The second illustration occurs on Black Hambleton, for there is very little Bracken on the northern slope of this hill, Bilberry and Heather being the chief plants, but the fern becomes more abundant on the western side.

From these facts it naturally follows that in valleys running east and west there will be differences in the plant life of their slopes, those facing north should be dominated by Bilberry, those facing south should exhibit a greater preponderance of Bracken ; and this is the case, though other factors often obscure the differences. They are fairly well-displayed in Stockdale which falls eastwards into Westerdale, a moorland gill which possesses the peculiarity of having an angular slope on both sides of the stream. This feature is also shown in our view of Grain Beck (Fig. 53), where we observe a steep bank rising from the stream which has cut a deep ravine, and above the edges of which are more extensive and gentler inclinations. In Stockdale, the northward-facing side, in its steeper

ascent, is gouged into slight hollows in which flourish luxuriant beds of Bog Moss and Rushes. Springs have excavated these hollows in the rocks, and the ridges between them are covered with Bracken broken by patches and strips of Heather. When traversing such a slope the investigator is often delighted with glimpses of these mossy depressions with their tall Rushes, cool green tones, and occasional exquisite little Junipers or Rowans growing in their shelter. Above this slope on the same side of Stockdale is a stretch of flatter ground where Ling comes in, and although the ascent is afterwards much steeper, it is all clothed with the same plant except for some large patches of Bracken. Higher up the valley Bilberry replaces the Bracken, but even here Heather is the chief species.

The slope facing south differs from the preceding in having much less Bilberry, Bracken being more numerous and reaching to the highest point above the valley. Juncus swamps exist on this side, but are not so frequent as on the opposite slope.

We must not omit to mention the effects of impervious strata on the vegetation. The outcrop of the Kellaways Rock shows this very clearly, for at its base it is, in some localities, as at Eller Beck, quite shaley; and this shale throws out in the form of springs, water which has percolated through the pervious sandy beds above, thus originating wet lower slopes clothed with Sphagnum bogs and beds of Rushes which run along the valley sides. In North Cleveland, where the Cornbrash, the stratum below the Kellaways Rock, consists of shale, its outcrop on the moors can be readily traced by the line of green bog vegetation running along the slopes.

Rushes and Bog Moss are the chief peat plants of the hill sides; but, in some places, where slips have taken place and ledges been formed, other species will appear, as shown in the photograph of the Cotton Grass in Fig. 19, which represents a peat-filled ledge on the western side of Danby Dale,

near the solitary cottage called St. Helena. Extensive slips of rock stretch along the dale slope for a mile or more, and on the undercliff thus formed, water has collected and peat has accumulated with a corresponding vegetation.

Our account of slopes must close as the preceding chapters have done, with a table of the different plant associations which clothe them :—

Pure Bracken slope.
Bracken, Grasses, and Gorse.
Bracken and Ling.
Bracken, Ling, Bilberry and Cowberry.
Bracken with scrub of Oak, Birch and Rowan.
Birch woods with Bracken or Bilberry nndergrowth.
Oak-birch woods with Bracken or Bilberry undergrowth.
Larch and Scots Pine woods with Bracken or Bilberry undergrowth.
Bilberry slope.
Junceta or Rush bogs with Sphagnum.
Cotton Grass and Heather, oecasionally on peat ledges.

Sometimes, it may be added, the woodland undergrowth is largely occupied by Heather, as in Sloethorn Park at the eastern end of Baysdale, but the variations in the proportions of the different species are so intricate as almost to defy exact classification. Though we may regret this from the point of view of accurate description, it is otherwise when we regard it as furnishing important keys to the development of types of vegetation. The most conspicuous facts which this chapter has disclosed are that Heather is of minor importance on most slopes, Bracken being the principal species with the Bilberry as a secondary dominant ; and the almost universal occurrence of solitary trees, scrub and woods, proves that all or nearly all the slopes were once fully clothed with trees. Naturally a discussion of the former forests of the Eastern Moorlands might here follow ; but before we enter upon this, it will be well to study some further aspects of the vegetation of the moors which throw more light on this interesting but obscure

problem. We shall, therefore, in the next chapter, review all the evidence concerning the origin of moors from woods and forests. It suffices here to note that in this chapter we have examined associations that are a long way removed from the kinds of moors with which we began the study of the plant life, and yet, as we have repeatedly seen and emphasised, insensible transitions unite all extremes.

Photo by] FIG. 22.—HEAD OF EWE CRAG SLACK, LOOKING NORTH. [*Godfrey Bingley.*

CHAPTER VI

SLACKS AND GILLS.

IN the four preceding chapters, we have surveyed practically all the plant associations which comprise the different kinds of moorland. The instances given have been obtained from all parts of the district; but it is quite possible to study many of the types within a limited area, where, owing to the physical features, most of them have been developed. Such a remarkable congestion of plant associations we find in small valleys, locally termed "slacks," which, on the North Cleveland moors, in the Vale of Goathland, and on the eastern margin between Robin Hood's Bay and Harwood Dale, form a very striking feature of the moorland scenery. The general appearance of these valleys is shown in Figs. 22, 23, 28, 29, 30, 32, and 64, and it will be observed that they all possess broad, flat, streamless floors and steep slopes. Geologically the slacks are of unique interest, being the old overflow channels of glacier-lakes during the Ice Age, and we shall further discuss them in the next chapter. For the present we shall confine our attention to their plant life, at the same time passing in review the types of vegetation we have so far dealt with.

We propose to describe in some detail the vegetation of Ewe Crag Slack, a great winding ravine, over a mile in length, which crosses the North Cleveland watershed due north of the village of Danby End, and which falls into Eskdale (Figs. 22 and 23). Where it traverses the watershed, as shown in Fig. 22, it is about twenty-five feet deep, but in its lower reaches it is from fifty to seventy-five feet deep, whilst the breadth of the flat floor rarely exceeds 150 yards. In this slack we meet with an epitome of the whole vegetation

of the moors, pure Heather moors, Bracken slopes, Sphagnum bogs, Juncus swamps, Cotton Grass bogs, and Tetralix moors. To enable the reader to follow our account of the vegetation we have prepared a small diagram (Fig. 24) indicating the position and distribution of the various plant associations.

And first it should be observed that the absence of a definite stream in the valley has given rise to special soil conditions. The slight fall of the slack and the accumulation of water on its floor have led to the formation of a vast bed of peat, extending throughout its length. Professor Kendall made a series of borings in this peat, and from them we learn that at the head it attains a thickness of 21½ feet, diminishing to 8½ feet and less near the outlet into Eskdale.*

In the lower reaches where a small stream oozes from the peat, the latter is covered with sand and sandy clay, and as a consequence, the floor is there clothed with little else than Bracken which forms the chief species of the slopes for some distance up the slack. Gradually, however, it becomes thinner, and tends to occur in patches towards the valley head, where the slopes are less pronounced and covered with peaty Heather moors. At the lower end, a few Hollies and Thorns alone remain of the wood which formerly filled a large part of the slack, whilst amongst the Bracken grow a variety of plants, Hard Fern, Ling, Bilberry, Cowberry, grasses and other species.

Restricting our attention to the floor as we proceed upstream, we find that the Bracken becomes less abundant, being here broken by large masses of Heather, and there ousted by Juncus swamps or Junceta. The fern disappears from the bottom of the valley at the point indicated on the diagram, above which it is confined to the slopes. From here to the head of the slack an impassable bog entirely covers the floor. First, we have a very wet Juncetum

* Kendall, "System of Glacier Lakes in Cleveland Hills," Q.J.G.S., 1902, p. 519.

Photo by] FIG. 23.—EWE CRAG SLACK, LOOKING SOUTH. *[Frank Elgee.*

composed of the Common Rush (*Juncus conglomeratus*) and also beds of *Sphagnum recurvum*, which latter, in places,

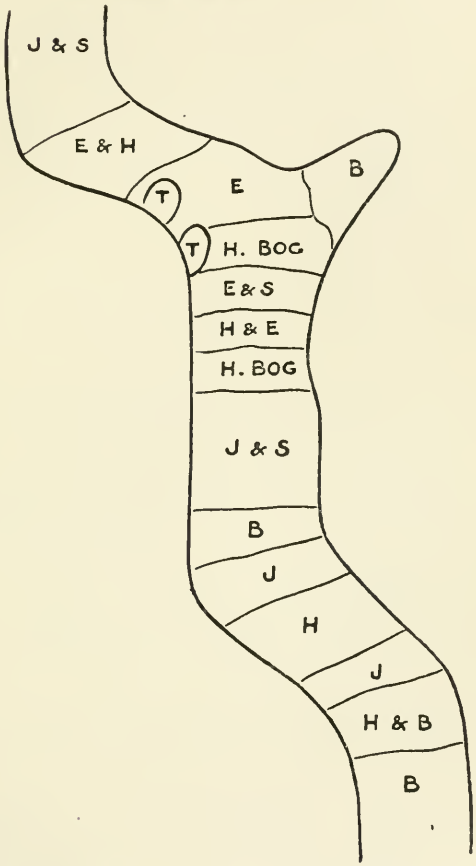


Fig. 24.—Diagram Showing the Distribution of Plants in Ewe Crag Slack.
J = Juncus; E = Cotton Grass; T = Pink Bell Heath; B = Bracken; H = Heather; S = Sphagnum.

forms pure Sphagneta, though of course on a very small scale. Next comes a patch of bog that is slightly drier,

and that is dotted with characteristic clumps of Heather followed by another area on which Cotton Grass (*E. vaginatum*) becomes numerous. This species prevails more or less to the head of the slack, and an examination of the diagram shows that in one spot it flourishes with Sphagnum, in another it is practically pure, and then again becomes interspersed with Ling. On the last area marked E. and H. in the diagram, pools of peaty water present a characteristic appearance. Surrounded by Heather, they contain a quantity of floating Bog Moss and tufts of Cotton Grass (*E. angustifolium*), whereas on the site of absorbed pools are Bog Moss, the other species of Cotton Grass, and Ling. A great bog of Juncus and Sphagnum occupies the head of the slack where the Commondale-Whitby road crosses it.

Beyond the middle of the valley to its head, it is most interesting to notice how Rushes fringe the border of the peat bog, clinging to the foot of either slope. We might almost imagine the two great Juncus swamps, the one at the head and the other at the centre of the slack, as sending out delicate tentacles of Rushes along either slope to keep in touch with one another, and as endeavouring to encompass the Heather and Cotton Grass bog, but that the feelers are occasionally interrupted, especially at the base of the western slope where we find two small but typical Tetralix moors (T in the diagram). One has much Cotton Grass (*E. vaginatum*) fraternising with the dominant Pink Bell Heath (*Erica tetralix*), and is quite destitute of Heather, though this plant occurs somewhat plentifully in clumps on the adjacent bog. These two patches of Pink Bell Heath are sharply marked off from the surrounding vegetation, and occur on swiddens, to the burning of which they evidently owe their origin.

Variations in the amount of surface water account for the greater or less abundance of the Heather amongst the Cotton Grass on the peaty areas ; but I think the presence of Juncus is largely due to the quantity of dissolved mineral

matter, though the water may at the same time be peaty. The circumstance that the principal areas of Rush prevail where the drainage is more active, where the water of the slack drains away in narrow streams both north and south, and where the aeration and amount of mineral matter may therefore be greater, suggests this conclusion.

On the whole the vegetation of this remarkable valley is essentially bog vegetation, for only in its lower reaches do we meet with dry Bracken and Heather moors on the floor; and what is typical of Ewe Crag Slack is typical of nearly all slacks of this character. Cotton Grass moors (*Eriophoreta vaginati*) prevail, and reproduce at much lower levels and on a smaller scale the Mosses of the central watershed, proving conclusively that altitude has no direct influence in determining their origin, bad drainage and the accumulation of peat being the chief factors. Thus the great valley of Moss Swang between Egton and Goathland is only 625 feet above sea level, yet its wide floor is covered with a great peat bed on which flourish masses of Heather and Cotton Grass (Fig. 28). There is no free natural drainage. In the same figure we notice the bracken-clad slopes with an incipient scrub of Oak, Birch, Thorn and Rowan.

The great cañon of Newton Dale, at its head, is the most remarkable of all the slacks. Here, the valley bears the suggestive name of Fen Bogs, a huge badly-drained morass, 2½ miles long and not less than 200 yards wide. The peat is very thick—at Fen Bog Houses 16½ feet; further south it is said to be sixty feet, the depth to which piles were driven during the construction of the railway.* The upper part of Fen Bogs supports a Heather, Cotton Grass and Gale association with great spreads of *Molinia*, bordering the railway; but lower down a distinct type sets in, including huge Reed beds (*Phragmites communis*), Reed Mace (*Typha latifolia*), and many

* Op. cit., p. 503.

species of Sedge (*Carex*), especially those characteristic of "fens" and Reed swamps. In fact, Fen Bogs is unique in North-Eastern Yorkshire, for it is the only locality within the moorlands that supports any considerable "fen" and Reed vegetation. The probability is that we have at Fen Bogs a local example of the transition of peat moors into "fen" vegetation, a stage that may have characterised all the slacks at an earlier period. But of this we cannot be certain until the plant distribution of this remarkable locality has been more thoroughly investigated.

In other slacks, the type of vegetation that dominates the floors is the Juncus swamp with its tall Rushes (*Juncus conglomeratus* and *effusus*, principally), and great undergrowths of Bog Moss. This is well shown in the view of Hardale Slack on Roxby High Moor, in which the light-coloured Rushes on the floor stand out in distinct contrast to the darker Heather and Bracken slopes (Fig. 32). On Girrick and Easington Moors, the same plants extend for a mile or two in a shallow valley with heather-clad land on all sides. The Rushes thickly cover the flat floor, now and then interrupted by patches of Cotton Grass and small Carex bogs. Between the Heather moor and the Rush bog there is usually a drier area clothed with Mat Grass and Heath Rush (*Juncus squarrosus*), the latter species almost invariably occurring in less moist situations than its congeners, whilst the former species often spreads over drier parts of the slack to the exclusion of the tall Rushes.

Other Junceta are characterised by a more open growth of the plants; Bog Moss is common, over which creep the reddish trailing stems of the Crowberry, further species of this association being the Marsh Pennywort (*Hydrocotyle palustris*), Mat Grass, Brown Bent, Ling, Pink Bell Heath, and Tormentil.

The head of Rudland Slack, between Farndale and Bransdale, is occupied by a fine Juncetum; and as the road

Photo by] FIG. 25.—BIRCH WOOD AND JUNCUS SWAMP, ESTON HILLS. *[Frank Elgee.*

between the two dales passes through it, we are enabled to observe the bog in all its details. Above the road gutter rises thick peat with great cushions of green Sphagnum on its surface, from which spring the tall Rushes thickly clustered together. The section is dripping wet, and water all shades of brown and often iridescent with the humic acids it contains trickles down into the gutter.

Sleddale Bog, near Highcliff, on the edge of Guisborough Moor, is another vast Juncus swamp ; but it is needless to describe further instances of a type of vegetation which is almost universal on the moors in suitable situations.

Slacks similar to Ewe Crag, Moss Swang, and Hardale, are numerous on the moor edge behind Robin Hood's Bay, the chief of them being the great ravine of Jugger Howe Dale which runs from near the Flask Inn to Harwood Dale (Fig. 64). They also present similar botanic features, with this noteworthy difference, however—Sweet Gale grows in profusion on their swampy floors, especially near the small streams which many of the valleys contain, owing to their larger size. Thus, Biller Howe Dale, forming the upper reaches of the Jugger Howe Valley, has in its highest parts no Gale amongst the Ling and Cotton Grass ; but further southwards, where a small stream flows down the centre of the ravine, the plant is quite abundant. In Fig. 64, in the left background, is the hill of Brown Rigg, an isolated mass of land bounded by Jugger Howe Dale on the right, and by a large semicircular shallow slack on the left, a slack which is at an elevation of seventy feet above the floor of Jugger Howe. In this loop valley, Heather and Cotton Grass are dominant, but there is no Gale, though the plant is not rare in other slacks in the same neighbourhood. And here we may remark on the singular distribution of this characteristic bog plant in the moorland area. As observed above, it usually occurs in slacks and shallow valleys which possess small streams, but this is only in the south-eastern part of the moorlands. It is found throughout Jugger Howe Dale,

as far as Harwood Dale, being frequently met with in branch valleys, such as Bloody Beck. It also extends down Newton Dale, from Fen Bogs nearly to Pickering ; it flourishes in the lower reaches of Brocka Beck and Eller Beck, near Goathland, where it is also found on the Gale Field. It characterises every branch of Wheeldale, except perhaps Wheeldale Gill, whilst it is found in boggy localities at the foot of the Tabular Hills as far eastwards at least as Lowna at the lower end of Farndale. It does not appear to occur elsewhere on the moors, for I have not observed this plant on the North Cleveland or the central watershed or on the western moors, although there are innumerable habitats suited to its growth. Especially is this absence to be noted in the northern slacks, since many of these resemble in almost every physical and geological detail those in the vicinity of Robin Hood's Bay where the Gale is so abundant. So far as present observations reveal, if we draw a line from the lower end of Farndale (where this valley breaks through the Tabular Hills) across Spaunton Moor to Black Rigg on Wheeldale Moor, thence to Goathland and to Brocka Beck on Widow Howe Moor, and from the latter locality to the head of Iburndale and Jugger Howe Dale, we shall have indicated the limits of its distribution by a boundary north-west of which it has not yet been observed. I have used the words, so far as present observations reveal, advisedly, for it may exist in small patches elsewhere, so that the line drawn must be regarded as merely approximate. Why the plant should be so distributed cannot at present be determined, since every attempted explanation is contradicted by opposed facts. It cannot be due to differences of habitat since these seem to be the same in the east as in the west, in the north as in the south ; it cannot be altitude, for it grows at an elevation of 1800 feet in Scotland ; it cannot be climate, for a similar reason ; and if it be urged that this part of the Eastern Moorlands is more congenial than the north and west, we find that the plant is somewhat rare in the south

and east of England. The problem is one that can only be solved by a careful study of its ecology and distribution throughout the British Isles.

A typical haunt of the Sweet Gale is Tranmire Slack, due north of Lastingham, where it is abundant, occurring in damp places amongst the Heather. In one place a Sphagnum bog, with a little *Juncus*, had clumps of Sweet Gale growing upon it, together with a few plants of the Pink Bell Heath, and the Gale was quite abundant round the edges of the bog.

Tranmire Slack presents many interesting features of moorland plant life not observable in the northern parts of the district. Looking at the valley from an adjacent height, the first impression we obtain of the vegetation is the superlative dominance of *Calluna* from the highest to the lowest slopes. The Bracken manages to exist on the immediate sides of the streams, and occasionally sends out long tongues into the Heather. Lighter patches indicate the presence of Tetralix swiddens, whilst darker green blotches mark the presence of Sweet Gale in wetter spaces. A feature of this locality is the great abundance of the Moor Sallow (*Salix repens*) amongst the Ling.

Without exception the remains of trees, principally Birch, more rarely Oak, are always met with when the peat of the slacks is cut (Fig. 29). From this circumstance we must conclude that at no very distant period all these valleys were more or less clothed with Birch and Oak wood very much resembling types presently to be described. The largest deposit of slack peat, as already mentioned, occurs at Fen Bogs where Birch trees have been excavated ; and, in fact, they still grow in places on the bog. Oak trunks have been found in Randay Mere (Fig. 30), and also in Roxby Peat Holes (Fig. 32), according to the Geological Survey ; but wherever sections can be seen, the white Birch bark is always in evidence in almost every peat-filled hollow. In Cowgate Slack, near the Falcon Inn, Birch scrub still flourishes in abundance ; and we may form a good idea

of the appearance of many of the slacks when they were filled with trees, by an examination of those wooded gills which, at the dale heads, run far into the heart of the high moors. They also afford us instances of the last types of vegetation which we shall describe in these pages; ericetal plants form a luxuriant verdure beneath the trees; and there can be no question that they are of extreme importance in furnishing evidence wherewith to explain the botanical changes which the moors have undergone.

Before describing the wooded gills, attention must be directed to two woods of particular interest; one on the Eston Hills at their eastern end, and the other in Rosedale. In the first Birch is dominant though somewhat dwarfed owing to the elevation, 650-700 feet, and to the exposed situation (Fig. 25). It flourishes on both damp and dry ground, and partially surrounds a shallow pond filled with the Common Rush (*Juncus conglomeratus*), with an occasional cushion of Bog Moss growing round the base of the plants. Under the trees shown in the illustration there is little vegetation except thin grassy spaces of Sheep's Fescue Grass and Wavy Hair Grass, and in the dampest parts there are not even these species. In more open parts, the two grasses with occasional Flying Bent (*Molinia cærulea*) and Common Rush occur, whilst towards the northern edge of the wood, Crowberry is very conspicuous, forming a carpet beneath the trees, spreading over old stumps, and even growing up and around the Birch trunks. Over an old stump this species and the Purple Bell Heath were struggling for mastery, and one plant of the former measured no less than ten feet by eight!

On the eastern side of Rosedale, not far from Cropton, another type of wet Birch wood occurs, which, however, I have not been able to study very closely. It differs from the preceding in the almost entire absence of Crowberry and in the presence of an abundant undergrowth of Sweet Gale, Flying Bent, the Pink Bell Heath, and other species.

Slacks and Gills

Our last type of moorland in North-Eastern Yorkshire is by no means the least important. Characterised by an abundance of Oak trees, with an undergrowth of ericetal plants, it generally flourishes on stream slopes or in narrow gills branching from the dales and penetrating far into the moorland. A fine example is that singular off-shoot of Baysdale, Great Hograh, lying about four miles west of Castleton (Fig. 26). Here we have a narrow valley with a small but active stream falling into the main dale from the south, the whole of the ravine being well-wooded. The chief tree is the Oak, next comes the Birch, and there are a few Mountain Ashes, and one Scots Pine. These trees do not pass out of the ravine on to the level moors on either side, though occasionally seedlings will be found at some little distance from the edges. Towards the summit of the slopes the Oaks become stunted and spread out their branches in curious zigzag forms. The highest trees do not grow above the level of the top of the gorge as they cannot stand exposure to the wind.

The most striking feature of the undergrowth is the abundance of Bilberry which attains a vigorous development and frequently a height of four feet. The richer soil of the slopes, the shelter of the trees, and the good drainage, may account for the luxuriant growth of this plant ; since, at the summit, beyond the trees, though still abundant, it is much smaller. Here, however, its congener, the Cowberry, is well dispersed amongst it, together with Bracken. In late August the ground is often scarlet with the bright berries of this interesting plant.

Further eastwards, another small valley, Little Hograh, falls into Baysdale. Botanically resembling Great Hograh, it differs from it in being more open and less wooded. Birch is the dominant tree in Little Hograh, though Oaks are numerous. The Cowberry is plentiful, growing on the open slopes and beneath the trees ; and Bracken, as a rule, caps the valley walls, with fat moors beyond.

These two valleys may be taken as typical of the vegetation which we are describing; the Birch or Oak is the principal tree, and the Mountain Ash is not rare. Such woods are closely related to those mentioned in the last chapter, and in fact they all constitute part of that ancient natural woodland which flourished like a green border round the edges of the dark moors. The wooded gills creep into the heather-clad areas, and constitute some of the most picturesque aspects of moorland scenery.

Why have the woods which formerly grew in the slacks disappeared, and how is it that such gills as Great Hograh still retain their trees? Here, at any rate, there can be no interference from man, except to a very slight extent; and it becomes obvious that the slack woods, the remains of which are found in the peat, must have been destroyed by natural causes. As we shall see in the ensuing chapter, many of the slacks were formed during the Ice Age, and consequently all the changes in their plant life must have taken place in post-glacial times. Geological investigation in various parts of Great Britain have led geologists to infer that important fluctuations of climate have prevailed since the Ice Age. If this has been the case it must have profoundly affected the character of the moorland plant communities. According to Professor James Geikie, the following stages represent the climatic changes that have taken place throughout Europe since the close of the Ice Age.*

Lower Forestian, or 4th interglacial epoch. Corresponds to the lower forests under peat bogs.

Lower Turbarian, or 5th glacial epoch. Corresponds to the peat deposits covering the lower forests.

Upper Forestian, or 5th interglacial epoch. Corresponds to the buried forests indicative of temperate and dry climates.

Upper Turbarian, or 6th glacial epoch. Corresponds

* "Great Ice Age, and Pre-historic Europe."

to the deposits of peat underneath the lower raised beaches, and over the last-named forests.

More recently, Mr. F. J. Lewis, in a series of papers in the "Transactions of the Royal Society of Edinburgh," has given a detailed account of the succession of plants in the Scottish peat, and according to him, the succession is as follows:—

Recent Peat.
Upper Forestian.
Upper Peat Bog.
Second Arctic Bed.
Lower Peat Bog.
Lower Forestian.
First Arctic Bed.

As interpreted by Professor Geikie and Mr. Lewis, the climatic changes indicated by these zones are as follows. After the Ice Age a warm and genial climate ensued, leading to the development of extensive forests; a recrudescence of cold and wet conditions led to the destruction of these forests by the formation of peat bogs which, on a further return of genial climates, bore forests on their surface. Finally, the present atmospheric conditions began to prevail, but, being slightly wetter than the preceding, caused the development of peat which once more destroyed the forests.

Until the peat deposits of the slacks and Mosses of North-Eastern Yorkshire have been carefully investigated, we cannot say whether there has been a succession of forests and peat beds as in the case of Scotch peat. All we know at present is that the peat of the slacks and moorland valleys contains the record of one forestian period, and the question now remaining to be considered is how these woods have been destroyed, and their sites converted into peat mosses and Heather moors.

Whether the water-logged nature of the floors of the

slacks at the beginning was caused by climatic changes, or was simply due to the gradual accumulation of swamp and bog at their heads—this slowly creeping down the slack, and so engulfing the trees—we have not yet been able to ascertain. But when we remember the vegetation of the Hograh ravine, it seems not unlikely that the latter process, quite independently of climatic changes, has been largely responsible for the destruction of the woods in the slacks. For if the climatic changes are the sole cause, if the transition from a warm and dry Forestian Epoch to a colder wet Turbarian Epoch produced the destruction of the Oak and Birch woods, why have these not disappeared from Hograh? The reason seems to be this. Great Hograh is a well-drained valley—a brisk stream flows down it. Under all changes of climate this circumstance will largely prevent the accumulation of peat and the decay of the trees. But in the slacks—especially those with broad flat floors—there is no definite stream and no free drainage for the water of their slopes. Hence Mosses would form, particularly at their heads where the fall is slight, and these would gradually creep down the valleys. Meanwhile trees would settle on the slopes, and in their lower reaches, and may even have extended to the heads of some of the slacks. The constant growth of the Moss and its slow movement downstream, accentuated by whatever climatic variations occurred, would in time destroy the trees on the floor, and only those on the slopes would survive where we still find them.

The head of Ewe Crag Slack, as will be seen in Fig. 22, is shallow, broad, and flat, and where it crosses the watershed the bog drains both northwards and southwards.

The main bog is fairly horizontal, and is very slightly, if at all higher in the centre than at the edges, and this we may expect in Mosses where lateral escapes for the water have existed. Lower down the valley it falls in a series of slight steps five in number. At three steps down the slope a stream emerges both from and below the surface.

Photo by] FIG. 26.—GREAT HOGRAH, BAYSDALE. [*Frank Elgee.*

Photo by] FIG. 27.—JUNIPER AND HOLLY TREES, BAYSDALE. [*Frank Elgee.*

After this stage the stream disappears underground, and is choked with boulders; still lower, not only is the peat drier, but it has been much eroded in flood times. These facts go to prove that originally the bog crept downstream, and that surface erosion now maintains it at a fairly constant level. Much that has been said concerning the Mosses of the watershed is more or less applicable to those in the slacks, but in their lower parts where the fall is steeper and the drainage better, the peat moss has been converted into Ling and Bracken moors.

If climate has been responsible for the change of vegetation, we have to imagine the slacks full of trees only during a comparatively dry period. Increased rainfall caused peat to develop, and to assist in the destruction of the woods in the way described. Doubtless both processes combined in their work of devastation, but until further investigations have been made, we can only surmise the actual course of events.

With the vegetation of the slacks and gills, we conclude our account of the plant life of the Eastern Moorlands. From what has been said, we have gained a sufficiently clear idea of the different kinds of moor, their conditions of life, and their mode of development. Many areas of heath vegetation have originated on bare sandy soils, others have formed in water, and yet others occupy the site of woods. Here it will, therefore, be well to bring together the facts and inferences concerning forests on the moors in post-glacial times.

That all the slacks, gills and dale slopes were once the site of woods and forests is incontestable. The presence of occasional trees, scrub and woods; the prevalence of Bracken and other plants of the Oak-birch undergrowth; and the remains of trees found in the peat all point to this conclusion. Even comparatively gentle inclinations were at one time wooded, as is testified by tree stumps in peat to the north of Danby Beacon, at an altitude of about

875 feet, a fact which indicates that much of the northern slopes of Easington High Moor, Roxby Old Moor, and Black Dyke Moor were once covered with trees though now quite treeless. The Birch and Rowan found in peat at the head of gills prove that the woods which are now in most cases restricted to the lower reaches formerly extended almost to the sources of the streams, as may be observed at an elevation of 1275 feet in Blakey Gill at Farndale Head, and at an elevation of about 1150 feet at Bluewath (see p. 83). The manner in which plantations of various trees flourish on the steep escarpments of North-Eastern Yorkshire is also indicative of the former condition of these localities, and their ability to support extensive woods, which, in prehistoric times, also filled the dales.

To what cause must we ascribe the disappearance of most of the natural woodland ? To a very effective cause—man. Where tree remains are found in peat, these have, of course, been entombed and the woods destroyed by the growth of peat bogs, but except in the slacks and at valley heads, this process has been very limited, and of comparative insignificance in the history of the moors. Nor does there appear to have been any replacement of wood by moorland through impoverishment of the soil due to the action of rain, and the formation of pan which would prevent a new growth of young trees. Climatic changes are scarcely likely to have operated within the period covered by this stage in the history of the moors ; hence we are driven to the conclusion that man has largely been responsible for the deforestation.

It is still within the memory of living people that the slopes of the dales and moors were more thickly wooded than at present, and the late Canon Atkinson relates that " thirty years ago he had heard an old man say ' Ah heared my au'd uncle offens say 'at he kenned t'tahm when a cat-swirrel could gan a't'way down fra Commondale End to Beggar's Bridge wivoot yance tooching t'grund.' "

Photo by] FIG. 28.—MOSS SWANG, LOOKING SOUTH. [*Frank Elgee.*

But the removal of trees probably goes back a long way. The large quantities of charcoal that would be required in early times, either Roman, Scandinavian or mediæval, for the manufacture of iron, would be obtained from the thick woods and forests of the dales, gills and slacks; and, apart from cultivation, may have been largely responsible for their ultimate clearance. Few people are aware of the extensive nature of the old iron smelting operations, the relics of which in the form of innumerable accumulations of slag, known as cinder hills, occur in nearly all the dales; and without paying particular attention to these interesting evidences of a past industry, I have noted them in Ryedale, Bilsdale, Greenhow, Baysdale, Danby Dale, Fryup Dales, Glaisdale, Goathland Dale, Farndale, Rosedale, and elsewhere. Most cinder hills occur on the slopes of the valleys, and the amount of wood and charcoal needed must have been very large. Combined with agricultural clearing and other causes, we may safely attribute the disappearance of most of the woodland of the slopes to this cause.

A different history is revealed when we turn to the high moors, the thin, fat and moss moors. On considering their superficial deposits as a whole, it must be admitted that they contain no evidence of ever having been covered with forests or even woods. Although time and atmospheric influences might cause innumerable stumps, trunks, and other parts of trees to decay and disappear—supposing for a moment that woods once existed on the uplands—yet to imagine that absolutely no traces have been left is highly improbable. It may be urged that as the peat at Bluewath and near Danby Beacon is known to contain trees, their absence from most other moors of the thin and fat types must be partly due to the absence of a sufficient depth of peat in which they could be preserved; and whilst this is perhaps true in a sense, yet when we remember that on Arden Great Moor, at Stony Ridge, on Danby Ridge, at Loose Howe, at Cock Heads, at Pike Hill

Moss, and even in the centre of Harwood Dale Moss, no remains of trees have been found, though in these places the peat is deep, I think, there can be little doubt that the higher wind-swept moors were never clothed with arboreal vegetation. Of course, this does not exclude the presence of occasional trees or scrub, for that such can grow on the open moors has before been pointed out; and as a further instance, I may mention the picturesque line of Rowans by the roadside between the Chequers Inn and Snilesworth Lodge. Moreover, our conclusion is in accordance with that reached in Chapter I., where we found that the course of the roads, the position of entrenchments, and the absence of villages on the moors, all indicate that two or three thousand years ago woodland was generally absent.

That woods formerly grew on a few of the lower flat Heather moors seems certain. For, apart from plantations principally of Scots Pine and Larch, which flourish so well in most places, natural wood and scrub often spring up spontaneously amongst the Ling. Near Three Howes on Harwood Dale Moor, numerous young Birches up to three feet or more in height, occur on a somewhat wet Heather moor with much Purple Moor Grass (*Molinia cærulea*). It would appear that these trees are self-sown, and are probably derived from Cowgate Slack previously mentioned. A factor which may have prevented the spread of this tree on the eastern margin of the moors is the sea-winds which, according to Mr. J. W. Barry of Fyling Hall, restrict its growth to within a mile or two of the coast wherever fully exposed to the north or north-east.*

The most remarkable feature in the ancient woods of the moors was the great rarity or total absence of the Scots Pine, a species that has been introduced by man. It seeds well amongst the Heather at the present day, and Mr. Barry, in the paper quoted, states that were it not for

* "Sylvan Vegetation of Fylingdales," *Naturalist*, 1908.

the moor sheep, turf paring and burning, the seed blown from plantations of this tree would give birth to natural woods. Our astonishment is not lessened when we learn that the Scots Pine *was* formerly indigenous to North-Eastern Yorkshire, for its cones have been discovered in the buried peat bed and forest of the coast at Redcar, a deposit which dates back to the Neolithic Period; and yet, with the solitary exception of the tree in the Harwood Dale peat holes, shown in Fig. 14, which I should regard as an old plantation tree, its remains have so far not been observed in the peat beds of the moors. If the remains of the Scots Pine really do occur at the base of our deepest peat that has yet to be examined, we may expect that it died out owing to those climatic changes which led to its extinction over most parts of England since Neolithic times. It may be remarked that in Scotland, the Upper Forestian layer though usually characterised by the Scots Pine is, according to Mr. F. J. Lewis, replaced by Birch at high elevations and in the extreme north.

The conclusion we have reached in this section of the work is that for many thousands of years, probably even since the Ice Age itself, the moors were islands and peninsulas of heath vegetation, surrounded by a great sea of forest and woodland, green feelers of which in the form of woods of Birch, Oak and Rowan, penetrated far into the heart of the uplands along the sides of the bubbling streams.

CHAPTER VII

THE ICE AGE ON THE MOORS.

IN the prosecution of our chief enquiry, the origin of the moorlands of North-Eastern Yorkshire, we have in the foregoing chapters traced some of their modes of development, on the bare ground, in water, and from woods. Given the requisite conditions of soil and climate, the special plants will form moors in the various ways described; and we may rest content with these explanations, and fondly imagine that we have solved the problem. A little reflection will convince us, however, that this is not the case, for the questions immediately arise, whence the plants which grow on the moors? Did they originate in the district, or did they enter it from elsewhere? and if so, when? The moor problem cannot be regarded as completely solved until we have attempted to answer these questions. But before we can do this, it will be necessary for us to bring geology to our aid, particularly that part of the science which treats of the Ice Age, and from which we shall learn how important the geographical conditions of Black-a-more, in past ages, have been in determining the existence of the moors.

We have already referred to this great climatic epoch incidentally. Its significance in the evolution of the moors cannot be under-estimated; for, quite apart from its effects upon the geology and scenery of the district, it has had a most profound influence upon the history of the moorland plants and animals. The actual features caused by the Ice Age are of importance in having originated some unique moorland scenes, and of yet greater importance in the proofs they furnish of the former presence of a large and complex "System of Glacier Lakes in the Cleveland Hills."

The Ice Age on the Moors

The chief peculiarity of the moorland region from the glacialists' point of view is that no deposits ascribable to ice action exist over the larger part of the area. Almost everywhere the moorland vegetation flourishes upon soils derived from the weathering of the rocks which are not overlain by boulder clay or other glacial debris. Moreover, no evidence of local glaciation has been detected in any of the great dales. The heads of Rosedale, Farndale, and Bransdale are the most likely localities where glaciers could have formed, but perhaps owing to the small gathering grounds, no rivers of ice ever travelled down these beautiful valleys. Nevertheless, it must not be overlooked that very small ice-streams may have existed in these dales, the traces of which may be difficult to discern because their moraines would consist of local debris, which, on being deposited on the hill sides, might therefore be indistinguishable from cliff detritus. In the eastern head of Farndale there occurs a series of remarkable lenticular mounds at practically the same level, on either side of the valley. It seems quite possible that these mounds may be the lateral moraines of a small glacier ; on the other hand they may have accumulated during the Ice Age owing to the rapid melting of snow on the slopes, or they may be due to landslips.

But if the high moorlands of North-Eastern Yorkshire were unglaciated far otherwise is it with the lowlands of the Vale of York, the plain of Cleveland, and a narrow tract bordering the coast from North Cleveland to Scarborough. Over these areas, the strata are more or less concealed by a deep mantle of glacial drift composed of boulder clay, sand, and gravel. Wherever the drift occurs, the ice-borne boulders it contains indicate the presence in Cleveland of a glacier from the west which brought characteristic rocks from Teesdale and the Lake District, the most important of them being Shap Granite. This glacier swept out to sea at the mouth of the Tees, but, owing to the southward movement of a great ice-sheet filling the North Sea, was

ultimately compelled to travel down the Vale of York. This diversion of the Teesdale glacier let in another ice stream from the north which had passed over a part of the Cheviot Hills, for in the higher levels of the Yorkshire drift, erratics of Cheviot Porphyrite and Magnesian Limestone are very abundant. The Cheviot ice swept up to the escarpment of North Cleveland, and down the Yorkshire coast, scattering its characteristic boulders and re-distributing those of the Teesdale Glacier.

Followed from the low grounds up to their boundaries, the drift deposits gradually become thinner and thinner as they rise along the slopes of the hills, until they disappear altogether. In the words of Sir Archibald Geikie, "these uplands appear to have formed an insular space round which the ice-sheets swept, but which remained unsubmerged." The South Cleveland watershed, the northern dales and the valleys of Rosedale, Farndale, Bransdale, Bilsdale, and Ryedale exhibit no trace of extraneous glaciation, and this area of ice-free country, termed the driftless region of North-Eastern Yorkshire, is one of the most remarkable features of the geology of the district, and has played a large part in determining the origin and distribution of the Eastern Moorlands.

Here and there the drift deposits do become conspicuous upon the moors, but only towards their northern and eastern boundaries, and they always indicate the position of the ice front at or near the period of maximum glaciation. On the Lockwood Hills, near Stanghow, large gravel mounds are conspicuous at an elevation of 875 feet, the highest point reached by the glacial beds in Cleveland. On Easington High Moor, north of Danby Beacon, is a fine gravelly moraine which must have stood in front of the great ice wall pressing against the northern face of the hills, and on Seamer Moor near Scarborough, occurs a similar moraine, shown in Fig. 62. Elsewhere erratic pebbles and thin layers of sand or gravel alone indicate the boundary of the drift.

Photo by] FIG. 29.—FOUL SYKE PEAT CUTTING, ROBIN HOOD'S BAY. [*Godfrey Bingley.*

Photo by] FIG. 30.—RANDAY MERE FROM THE SOUTH. *Godfrey Bingley.*

Some of these often occur at great heights. Thus pebbles of Cheviot Porphyrites are scattered amongst the Ling on the edge of Newton Moor above Guisbrough at an elevation of one thousand feet.

During the Ice Age, then, the moorland district presented the following aspects. Great rivers of ice abutted on the escarpments of the Cleveland and the Hambleton Hills, in the north-east of Cleveland these glaciers swept inland as far as the northern sides of Danby Beacon, but the watershed between this hill and Whitby was covered by the ice which welled up the Esk Valley to Lealholm. It also penetrated the Murk Esk Valley and Iburndale, and south of Whitby, pressed inland as far as the great ravine of Jugger Howe Dale. Beyond Scarborough the glaciers did not penetrate into the Vale of Pickering, which throughout the Ice Age remained unglaciated as did the high moorlands within the lines thus briefly indicated.

If the boundary of the drift is examined in North Cleveland, in the Murk Esk Valley, and in the coastal region between Robin Hood's Bay and Scarborough, a very remarkable feature is found associated with it. Coinciding with and parallel to the drift edge, moorland valleys of a striking and peculiar character are to be observed, the slacks of the last chapter. They are invariably flat-floored, independent of the present drainage system, at considerable elevations, and practically without streams. The streams that they formerly contained must have filled them from side to side, and must have, in many instances, flowed along the front of the ice sheet when this stood against the moor slopes. This kind of valley is shown in Figs. 28, 30, 32 and 64. Running from the drift edge are other similar valleys, cutting through watersheds and traversing the unglaciated country. These are shown in Figs. 1, 2, 22, 23 and 31.

Ewe Crag Slack is one of the latter kind. It contains no stream worth mentioning, its floor is broad and flat, and it passes through the North Cleveland watershed close to

the drift boundary on the northern side of the moors, a feature shown in Fig. 22. The stream that occupied and carved out Ewe Crag Slack, must, in its origin, have been very different from those which excavated the normal moorland gills and dales.

If, after entering the moors by way of Newton Dale, we had then been conveyed to the sides of Ewe Crag Slack, we should have at once perceived that the latter is very similar to the great ravine. In fact, the slack is a replica in miniature of the Newton Dale valley. Like Ewe Crag, Newton Dale at Fen Bogs cuts through a watershed; like it, Newton Dale has a broad flat floor; and yet again, Newton Dale flows away fron the area of glaciation in the Murk Esk Valley into the ice-free country beyond (Figs. 1 and 2).

As these slacks without streams run in directions contrary to those of the normal drainage of the district, and as they show by their disposition and configuration that the normal valleys were in existence when they were formed, it becomes clear that they must have been produced by some temporary alteration of the drainage. The intimate relation subsisting between the dry valleys and the drift margin indicates that the two are causally associated, for the glaciers which abutted against the uplands obstructed the rivers, and their waters, being unable to escape by their usual outlets, accumulated within the northern and eastern dales, as glacier-lakes, the overflowing of which along and from the ice margin, gave rise to that system of dry valleys so peculiar to, and characteristic of the Eastern Moorlands. When the glaciers finally vanished from the district, the obstructed drainage resumed its former courses, leaving the old overflow channels as silent witnesses of geographical conditions long since passed away.

To revert to Ewe Crag Slack. The ice pressing against the northern hills obstructed the drainage falling into the sea, and the water accumulating between the moor slopes

and the ice front was compelled to overflow the watershed into Eskdale. In time the great slack was excavated, and at its outlet into Eskdale is a large deposit of gravel—its delta—consisting of materials derived from the erosion of the gorge and erratic boulders from the ice itself. Simultaneously with the formation of the slack a series of channels drained from the Lockwood Hills towards Ewe Crag, but with the retreat of the ice, when the streams would resume their normal courses, these overflow channels and Ewe Crag Slack were left high and dry.

In Fig. 22 one of these related channels is indicated by the notch in the moor slope in the background whilst in Fig. 23, an excavation in the gravel delta is shown on the left-hand side of the valley at its far end.

We owe the explanation of the origin of these remarkable valleys to Professor P. F. Kendall, of Leeds University. In his celebrated paper on "A System of Glacier-Lakes in the Cleveland Hills," read before the Geological Society in January, 1902, he demonstrated the former presence of glacier-lakes in North-Eastern Yorkshire, and incidentally settled many vexed questions in British glacial geology. "A System of Glacier-Lakes in the Cleveland Hills" is one of the most important contributions ever made to our knowledge of glacial erosion, and must be carefully studied by all who wish to comprehend the fundamental significance of the Ice Age on the moors.

It is unnecessary for our purpose to give a complete account of Professor Kendall's investigations, and it will therefore suffice if we describe the interconnection of some of the most striking phenomena.

In Eskdale glacial deposits actually due to the presence of ice can only be traced upstream as far as Lealholm, where a fine terminal moraine crosses the valley in the form of a huge ridge, the southern end of which is severed by the Esk at the beautiful gorge of Crunkley Gill. In Kildale a similar moraine blocks the entrance to the

valley just west of the village. When the ice barriers at these places were in existence, the drainage of the valley from Kildale to Lealholm together with that of the northern dales would be obstructed, and would accumulate to such a depth until it would ultimately overflow the valley walls. In the case of a glacier-lake surrounded by hills of different elevations, this point of overflow must of necessity be the lowest, and as the escaping waters are sure to bear much sediment with them, a channel will be excavated in the rocks they pass over. Moreover in glacier-lake overflows the altitude of the channel so eroded will provide us with a clue to the depth and size of the lake. If, then, the Esk Valley and Kildale were obstructed in the way described, and a large lake formed in them, we must look for its overflow at the lowest levels left free by the invasion of the ice-sheet, and this is best done by tracing the boundary of the drift deposits from the moraines.

At Kildale the hills are much higher than in the neighbourhood of Lealholm, and if the drift margin is examined no traces of any overflows are to be found. Turning to Lealholm, we find that the boundary of the drift falls in a south-easterly direction from the moraine across the mouths of Glaisdale and Egton Grange, and along the slopes of Murk Mire Moor, a tongue of land dividing the latter valley from that of the Murk Esk. This moorland ridge has the lowest elevation of any of the ridges dividing the northern dales at their confluence with the Esk Valley, and consequently, as the drift only touches its lower end, we find thereon exactly in front of, and parallel to what we know must have been the ice front, a series of dry valleys of a very remarkable character.

High up on the moor, at an elevation of 725 feet, begins the first of the overflow channels which drained Lake Eskdale. Opening on the steep slopes of the Egton Grange valley, now of course streamless, and known as Lady Bridge Slack, it runs south-eastwards against the general inclination of

the moor which is in the opposite direction. This independence of the overflow channels of the topography constitutes one of their most remarkable and note-worthy characteristics, and points conclusively to a special mode of origin due to the presence of ice barriers.

The overflow continues along the side of the moor to Hazel Head at the entrance to Wheeldale, where there is no definite channel, but a series of gravel mounds in front of which the overflow took place.* The distribution of the drift in the valley of the Murk Esk shows that a great lobe of ice welled up this dale as far south as Two Howes Rigg, above Goathland. Along the western margin of this ice lobe the channel on Murk Mire Moor was excavated at a considerable elevation above the floor of the valley. As the intake of Lady Bridge Slack stands at 725 feet on the moor edge, the water that flowed down it must have reached that altitude in Eskdale *before the overflow could have commenced.* In other words, since Lady Bridge Slack is over 400 feet above the average level of the floor of Eskdale, Glaisdale, and the Butler Beck Valley, this latter as a rule being about 325-350 feet, it follows they were filled with water to a height of 725 feet. By tracing this line on the contoured maps of Eskdale, Professor Kendall has outlined the area occupied by the glacier-lake, and in his own language, " the evidence of these overflows proves that at the maximum extension of the ice a lake was held up in Eskdale to an altitude of over 725 feet ; and assuming that it extended no further than the gap at West Bank House in Kildale, it would have been about eleven miles long and not less than 400 feet deep ; it would have ramifications up all the tributary valleys. I propose for it the name of Lake Eskdale."†

Returning to the Murk Mire Moor channel at its outfall at Hazel Head, we find this occurs at about 670 feet. Stand-

* Kendall, p. 506.
† Kendall, p. 507.

ing at the farm known as the " Hollins," and looking across Wheeldale to Two Howes Rigg, we can see a square cut notch in the slope of the moor outlined against the sky. This notch forms the intake of another overflow channel, Moss Slack, falling eastwards across the end of the Rigg, the level of which at its intake is 675 feet, precisely the same as that of the outfall on Hazel Head. This coincidence means that the ice obstructing the end of Wheeldale, pounded back the drainage of that valley until a lake was formed, whose surface level attained an elevation of 675 feet. The drainage of Lake Eskdale, therefore, at the epoch of maximum extension fell into Lake Wheeldale, and Lake Wheeldale drained through Moss Slack, into another lake in the valley of Eller Beck, to which we shall presently refer.

The Murk Mire Moor channel being very shallow, it follows that the ice did not remain long in this position, or otherwise the valley would have been cut more deeply. In fact, it forms what Professor Kendall has termed " the touch and go stage," where the ice having reached its greatest elevation almost immediately fell back to a lower level. This lower level is represented on Murk Mire Moor by the dry gorge called Park Dyke Slack, a continuation of Lady Bridge Slack. We find that the two overflows are separated by the valley of Oakley Beck, a normal stream falling into the Murk Esk. The contours show, and it can be verified by mere inspection, that the outfall of Lady Bridge Slack into Oakley Beck is lower than the intake of Park Dyke Slack on the opposite side of the stream ; the interpretation put upon this fact by Professor Kendall being that the ice retreated from the latter slack more rapidly than from the former, and was consequently eroded more deeply, viz., to below 700 feet, which proves, of course, that the great lake in Eskdale had been lowered at least twenty-five feet.

The next episode in the history of Lake Eskdale revealed by this remarkable piece of moorland took place after the

ice margin had melted back about a quarter of a mile from the higher slacks. Here another series of overflows at a lower level and parallel to the upper one was initiated, and the two great valleys of Moss Swang and Randay Mere were excavated by the then rapidly sinking Lake Eskdale. The road from Egton Bridge to Goathland runs along the eastern side of these fine relics of the Ice Age. Ascending the steep road from Egton Bridge until we arrive at the cross road leading to Grosmont, and turning towards the west, we have spread out below us the intake of the great Moss Swang valley. Arising on the moor edge high above the floor of Egton Grange, it points directly up Eskdale in the direction whence the impounded drainage came. On the northern side of the intake is the grassy hill, Lord's Seat, on which the ice must have stood, and in front of which the overflow must have travelled ; but on the eastern side of Lord's Seat, Moss Swang is quite open with a flat peat-filled floor and with a steep scarp on the moor edge to the south. From this circumstance it is to be inferred that the ice here " thrust forward against the lake-outflow."*

After this stage of shelf and scarp, Moss Swang turns southwards, and rapidly becomes a great cañon over 200 feet deep and quite streamless. The annexed photograph (Fig. 28) gives a clear idea of the valley which exhibits all the characteristics of lake overflows, distinguishing them from any valleys of normal erosion in North-Eastern Yorkshire. It has steep sides, a broad flat streamless floor, well seen in the illustration, and meanders, which show that the water flowing through filled the channel from wall to wall. At some period during the excavation of Moss Swang the ice at its southern end re-advanced across the valley, and compelled the overflow from Lake Eskdale to travel at a higher level. The evidence for this we find in an immense loop isolating the Castle Hill, formerly considered a fort by

* Op. cit., p. 485.

some local antiquarians! The photograph of Moss Swang shows this feature very well. In the immediate background lies the Castle Hill, whilst the depression to the right marks the intake of the higher channel—the oxbow as it is termed —fully fifty feet above the floor of the main valley. A further retreat of the ice margin re-opened the lower channel, leaving the oxbow high and dry as one of the most imposing relics of the Glacial Period in Cleveland.

Further along the Goathland Road we come upon the lower segment of the present overflow, which, like the higher overflow, is divided by Oakley Beck. This lower segment is the valley of Randay Mere (Fig. 30). Of course whilst these channels were being eroded the level of the great lake in Eskdale was being steadily lowered until it had sunk a hundred feet below its highest level. This fact is proved by the altitude of the Moss Swang outfall which stands at 625 feet.

But we have not yet finished the history of the overflows from the lake. We have yet to trace the further course of the escaping waters through that *magnum opus* of the Ice Age, the grand valley of Newton Dale, between whose precipitous walls the drainage of Lake Eskdale travelled for a long period.

It will have been noticed that the slacks on Murk Mire Moor all fall in one general direction, towards the south or south-east. It is evident, then, that the waters of Lake Eskdale must have had some ultimate outlet yet further southwards, and from its elevation, the lowest point of the South Cleveland watershed, the great Newton Dale gorge must be regarded as the main escape of the Eskdale system of lakes. Speaking of it Professor Kendall says :—" Newton Dale has long been an object of interest to me and of wonderment, because of its immense depth and the way in which it passes completely through the watershed. Reflecting upon these characters, with the light obtained by studies of glacial overflows near Ripon and Knaresborough, I was

Photo by] FIG. 31.—NEWTON DALE ABOVE LEVISHAM STATION. [*Frank Elgee.*

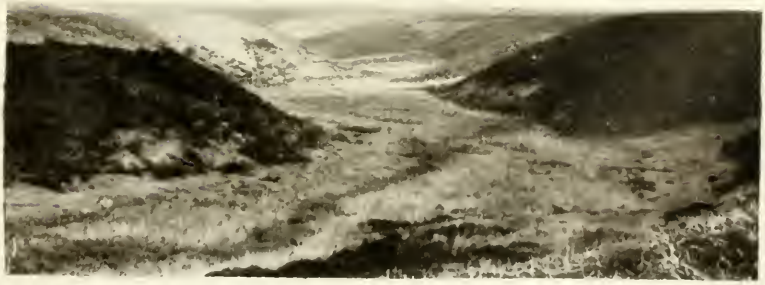


Photo by] FIG. 32.—HARDALE SLACK, ROSEY OLD MOOR. *Godfrey Bingley.*

brought to the conclusion that Newton Dale must be the overflow of a glacier-dammed lake in the Eskdale country. An inspection of a map showed that if the normal outlet of the Esk were closed, this would, by its altitude, be the outlet. This clue led to the unravelling of the whole chain."*

The great ice lobe which filled the Murk Esk Valley abutted on the end of Two Howes Rigg, above Goathland Church, at the same time damming back the drainage of Eller Beck and Wheeldale on either side of it. Lake Wheeldale drained by Moss Slack (previously mentioned) into the Eller Beck Lake which, in its turn, was obliged to overflow the southern watershed where Fen Bogs, the head of Newton Dale, now is. In pre-glacial times, probably no part of the dale above Raindale Mill existed; the moorlands of Goathland then extended in an unbroken line from west to east with small streams falling into Eller Beck on one side and into Pickering Beck on the other. The lake in the valley of Eller Beck rose to a height of 650 feet, the lowest point of the watershed, when it began to drain southwards into the Vale of Pickering. Along the line thus initiated, the upper portion of Newton Dale was excavated by the convergence upon it of the whole series of overflows from Lake Eskdale, and we may judge of the length of time which this took when we recollect that by Newton Dale the level of the lake was reduced from 725 to 525 feet; the latter level being determined by Professor Kendall from a series of borings in the peaty morass of Fen Bogs.

To walk down Newton Dale to Levisham Station is one of the most impressive geological excursions in the whole of North-Eastern Yorkshire. After leaving Fen Bog Houses the observer soon perceives that the valley, quite streamless, though much filled with swamp, rapidly deepens, until a depth of 400 feet has been reached. On either hand are steep slopes becoming sheer precipices of rock at the summit,

* "System of Glacier Lakes," p. 502.

and the whole scene is wild and rugged in the extreme. Mentally comparing it with the normal valleys of the district, such as Danby Dale or Glaisdale, the geologist finds that it differs from them in form, in drainage and in slope. Practically streamless, cutting through a watershed, and possessing immense bends, the head of Newton Dale for over three miles bears witness to the enormous volume of water which must have poured down it ; and if this valley alone had been adduced as evidence for Lake Eskdale we should have been compelled to accept the conclusion. It cannot be too strongly insisted upon that Newton Dale is utterly unlike any valley which normal stream erosion has produced on the Eastern Moorlands. To see this it needs but to compare the views of the great ravine in Figs. 1 and 2, with those of Baysdale (Figs. 52 and 53) and Winter Gill (Fig. 51) ; valleys that have been excavated by the streams now flowing through them.

It will enable us better to understand the valleys of the Ice Age, so mysterious in their upland calm and solitude, if we imagine that the Esk still continued to flow down them. We should find the river deviating from its course near Egton Bridge, flowing down Moss Swang and Randay Mere, and *via* Fen Bogs and Newton Dale into the Vale of Pickering. At the same time the Murk Esk Valley and the seaward end of Eskdale would be deserted by their respective rivers. What we have here imagined to be the case, has actually occurred to the Derwent along the edge of the moors between Harwood Dale and East Ayton. Here, the drainage of the moorlands was dammed up and formed glacier-lakes which overflowed along the ice margin into the Vale of Pickering. On the retreat of the ice, however, the overflows had cut so deeply that any resumption of flow along old lines of drainage was out of the question. Consequently, the rivers which formerly occupied the Symes and Sea Cut Valleys were turned aside, and now travel through the great river gorges of Langdale and Forge Valley ; and it is easy to see that the

Esk would have travelled in similar gorges if the glacial dams had persisted long enough.

Extraordinary as the phenomena of the Ice Age on Murk Mire Moor are, they are perhaps exceeded by the network of dry channels "cut" as Professor Kendall says, "by the overflowing waters of glacial lakes out of a gently sloping plateau of at present heather-clad moors," west of Robin Hood's Bay. Advancing up Iburndale beyond the Falling Foss, the northern ice sheet obstructed the drainage, and this escaped eastwards by Biller Howe Dale, which, turning southwards near the Flask Inn, becomes the impressive ravine of Jugger Howe Dale (Fig. 64). This latter valley was formed along the ice margin and runs from behind Robin Hood's Bay to Harwood Dale. Connected with it near Robin Hood's Bay is a complicated network of dry slacks which record the fluctuations of the ice front in a very clear manner. To describe them here is impossible; but some idea of this piece of moorland country may be conveyed when it is borne in mind that in a very small area no fewer than a dozen overflow channels and three oxbows (one of these Brown Rigg, is shown in the left background of Fig. 64) occur, most of them of large size. Professor Kendall states that these remains "impressed him more than any other illustration of the effects of the Ice Age that he had seen," and with this opinion we must agree. A more remarkable piece of moorland it would be difficult to imagine.

Mention must also be made of the great parallel valleys on Hardhurst Moor, west of Hayburn Wyke. All indicative of stages in the recession of the ice margin from Jugger Howe Dale, they traverse from north to south the spur of moorland lying between Staintondale and the Symes Valley. First we have Cowgate Slack near the Falcon Inn; then further eastwards comes Hardhurst Slack followed by the Ringing Keld Valley. A continuation of this latter southwards is the "magnificent gorge of Oxdale Slack, nearly a mile long, and not less than seventy-five feet deep near

the intake, which gashes completely through a bold spur composed of hard and massive grits forming the last limit of the Lake Hayburn watershed. There is scarcely any more instructive and convincing example to be found in the district than this wild rocky gorge sweeping completely through from side to side of the hill " (Kendall) ; and there are other gorges at lower levels.

In North Cleveland similar features occur. Ewe Crag Slack is one ; and on the northern slopes of the moors evidences of glacier-lakes are to be met with in numerous dry valleys, of which Hardale Slack (Fig. 32), Tranmire Slack, and Moss Syke Slack are the most striking.

Various minor changes were produced during the Ice Age, of which perhaps the most interesting is Stony Moor, at the foot of the Tabular Hills below Newton-on-Rawcliffe, and on the brink of Newton Dale itself. In July 1906 when I first visited this locality I was much surprised at the quantity of boulders, large and small, which cover the moor. Inspection showed, moreover, that they consisted chiefly of Estuarine grits and sandstones, whereas the rock they reposed upon was the Kellaways. Among them I also detected some large pebbles of quartz and quartzite. At the time I was quite at a loss to account for this phenomenon ; but in a paper published in the " Proceedings of the Yorkshire Geological Society for 1905," Mr. J. T. Sewell, of Whitby, showed how the presence of these boulders could be explained by a high overflow out of the head of Wheeldale. This overflow took place through a peat-filled channel known as Slavey Slack between Brown Howe and Wardle Rigg separating Newton Dale from Wheeldale. The rush of water down the slack brought with it the boulders which were precipitated on the Kellaways Rock of Stony Moor.

We have only been able to give a mere outline of the geological effects of the Ice Age on the moors. However surprising it may seem to those who have not paid special

attention to the subject, we can assure them that it rests on incontrovertible evidence. Numerous workers in all parts of Europe and North America have established the former existence of an age of intense cold which may date back from 10,000 up to 100,000 years ago; and though many special problems are still unsettled, we may regard the Ice Age as an ascertained and indisputable stage in the Quaternary history of the northern hemisphere.

CHAPTER VIII

THE ORIGIN OF THE MOORLAND FLORA.

HAVING gained some knowledge of the Glacial Period and its effects upon the moors, we are in a position to begin our enquiry into the origin of the chief moorland plants and their relation to that period. Veiled in the obscurity of past ages as their origin is, yet it can be partially discovered by the consideration of the following lines of evidence :—their geographical distribution, their conditions of life, their geological age, and the fluctuations of climate in Tertiary and Quaternary times. In this way some idea can be formed of the evolution of the ericetal flora ; though the conclusions reached must be largely speculative as this branch of our subject is beset with peculiar difficulties, chiefly arising from the lack of fossil remains which would furnish clear evidence as to the history of the plants in question. Facts relative to the origin of the moorland flora are not yielded by its local aspects ; hence the necessity for treating the problem generally. All available material from every part of Europe must be surveyed before we can possibly arrive at any solution, and even after we have done this we shall still be uncertain about many essential points. Taking the Glacial Period as the central point in this enquiry, we may divide the history of the moorland plants into three stages—the pre-glacial, the glacial and the post-glacial. Not that any hard and fast line can be drawn between these stages, but they constitute convenient though vague chronological divisions which will be most useful to us. We have in earlier chapters considered the events in the post-glacial history of the moors, and we now propose to carry back

the history to a time when the plants did not exist, and follow their gradual development through the ages.

And first we must treat of their geological age. Thanks to the researches of Mr. Clement Reid, a great many British plants have been detected in various Quaternary deposits in different parts of the country, and with facts drawn from other sources, the following is all the information I have been able to collect concerning the age of some ericetal species.*

The two Heaths and the Heather have not yet been recorded in the fossil state, unless we call the remains of Ling found by Mr. Lewis, at the base of some peat beds in Scotland, fossils. These remains of Heather occur above the boulder clay, and seem, in some instances, to have been the first plants to colonise the ground after the Ice Age.

The Vacciniales are frequently found in Quaternary formations, and the following are the facts relative to their geological history :—

Bilberry (*V. myrtillus*) German late glacial deposits.

Cowberry (*V. vitis-idæa*) German late glacial deposits, and in Swedish neolithic deposits.

Cranberry (*V. oxycoccus*) German inter-glacial and Swedish neolithic deposits.

Greater Bilberry (*V. uliginosum*) German inter-glacial and Swedish late glacial and neolithic deposits.

Bearberry (*Arctostaphylos uva-ursi*) English late glacial and Swedish neolithic deposits.

Other fossil records of ericetal plants according to the same authority are :—

Tormentil (*Potentilla tormentilla*) English inter-glacial beds.

Dwarf Cornel (*Cornus suecica*) Swedish late glacial beds.

Thyme (*Thymus serpyllum*) Swedish late glacial beds.

Sheep's Sorrel (*Rumex acetosella*) English pre-glacial beds.

* C. Reid, "The Origin of the British Flora."

Gale (*Myrica gale*) German inter-glacial beds.
Birch (*Betula alba*) English pre-glacial to recent deposits.
Crowberry (*Empetrum nigrum*) Swedish inter-glacial beds.
Scots Pine (*Pinus sylvestris*) English pre-glacial beds.
Juniper (*Juniperus communis*) German inter-glacial beds.
Tufted Club Rush (*Scirpus cæspitosa*) English pre-glacial beds.
Cotton Grass (*Eriophorum vaginatum*) German inter-glacial beds.
(*Eriophorum angustifolium*) English pre-glacial beds.
Bracken (*Pteris aquilina*) Tufas of Montpellier (Geikie) and Swedish neolithic deposits.

The whole of the evidence of the fossil flora of Britain, so ably compiled by Mr. Reid, shows that very few moorland plants date back to pre-glacial times, though the majority existed in the Glacial Period ; and, as we shall presently see, most of these are plants of northern distribution. Now palæontology thoroughly establishes the fact that most of the existing species of animals and plants had arisen in pre-glacial times ; that is to say, towards the close of the Pliocene period, and there can be little doubt that species whose remains have not been found in a fossil state also date back to the same period of geological history.

Palæobotanical records, however, only tell us what the age of any particular species may be, and at what particular geological period it was first known to exist. It is quite inadmissible to suppose that a plant's first appearance in the strata of the earth is indicative of the exact time of its origin, and for anything we know to the contrary, it may have flourished ages before its occurrence as a fossil ; and so far as the direct evidence concerning the moorland flora goes, we have no clue as to when this first began to be of importance in the vegetation of western Europe. The

facts we have just adduced have carried us up to the front as it were, and we are left facing a misty era in the history of the moors which is most difficult of interpretation; but a little consideration of some further palæobotanical data will enable us to define more clearly the probable time when the moorland species were evolved.

It is not necessary to go further back than the Eocene period, for, though flowering plants undoubtedly existed in Cretaceous ages, they throw no light whatever upon the present problem. The Eocene flora, which has been partially preserved in the Paris Basin, the west of France, and in the south of England, contains the first important indications of recent types of vegetation; that is to say, of genera flourishing at the present day in our latitudes. Amongst these are various species of Oak (*Quercus*), Alder (*Alnus*), Birch (*Betula*), Poplar (*Populus*), and Ivy (*Hedera*); but besides these there have been found numerous species related to forms still living in warmer parts of the globe, arborescent ferns, *Lauraceæ*, etc., together with extinct types such as *Dryophyllum*, *Dewalqueia*, etc. The flora has a distinctly tropical facies probably indicative of a much warmer climate. Hence no evidence in Eocene deposits throws any light upon the moor problem, except in a negative way. So far as North-Eastern Yorkshire is concerned, the moors could not then have existed for three reasons:— first, because the rocks on which the moors repose were covered by strata now eroded away and which would give rise to soils totally unsuited to ericetal plants; second, the climate was perhaps too warm for their proper development; and third, because the Eocene flora, though it contains many species of Gale (*Myrica*), does not contain any existing moorland plants. With regard to *Myrica* several forms have been recorded from the Lower Bagshot Beds of the south of England, *Myrica salicina* and *acuminata* being instances, though the first indications of this genus have been detected in the younger Cretaceous beds of North America.

According to Professor Schenk, these identifications are uncertain because the leaves of most species of *Myrica* possess no definite characteristics which would enable them to be assigned to this family.* Several fossil species have been identified with certainty as belonging to the sub-group *Comptonia*, represented at the present day by a single north American species, *Myrica asplenifolia* Br., a sub-group which does not include the Sweet Gale and which attained a rich development in Europe in Tertiary times, particularly in the Pliocene period.†

Passing next to the Oligocene flora, this, according to Zeiller, is characterised by types peculiar to warm regions, palms being specially abundant.‡ But the most striking feature of this stage of Tertiary history is the relationship which exists between many of its species and those living to-day, including such well-known plants as Junipers, Oaks, Beeches, Sallows, Elms, etc., which do not seem to have appreciably varied since then. The only true ericetal species appears to be *Andromeda*, which, amongst many localities, has been found in the intercalated plant beds in the basalt plateau of Antrim. *Vaccinium* leaves are recorded by the Marquis de Saporta from the Lower Oligocene of Camoins-les-Bains in France, but these are doubtful determinations according to Schenk.§

During the Miocene period, tropical types decreased in numbers, and deciduous trees and species closely related to those living in our latitudes to-day increased. Zeiller states that the European Miocene flora recalls that of North America, this continent and Europe being inhabited by almost the same vegetation. It is in this period that we meet the only recorded fossil Heaths, three species (*Erica deleta, Bruckmanni* Heer, *E. nitidula* A. Brg.) having been

* Zittel's "Handbuch der Palaeontologie," Abtheilung II, p. 833.
† Op. cit., pp. 452-458.
‡ "Eléments de Paleobotanique," pp. 352-3.
§ Op. cit., pp. 719-720.

described from remains found in the upper Miocene of Oeningen in Switzerland, whilst an allied species, *Ericophyllum ternatum* Con., has been detected in amber in Samland. Leaves of *Vaccinium* are numerous and this genus is supposed to have then attained its maximum development in Europe. But here again the critical examinations of Professor Schenk in the work already quoted have thrown a doubt upon the precise position of such leaves for they are characteristic of many other families and genera. Nevertheless the existence of the small inrolled ericetal type of leaf may be indicative of climatic conditions suitable to the evolution of plants found on moors.

The gradual cooling of the climate of western Europe, so clearly indicated by the faunas and floras of mid-Tertiary age, culminated during the Pliocene period in a climate somewhat similar to the present, as is proved by the occurrence of species characteristic of temperate Europe to-day. Though the adaptability of moorland plants enables them to flourish in very varied habitats throughout their range, yet it is only under specific meteorological conditions that moors properly so-called could have originated. As we have seen, these essential conditions are a considerable and constant quantity of rain with rare intervals of drought, and a low average summer temperature with a variable winter and short duration of frosts. As the climates of Eocene, Oligocene, and Miocene times were tropical or subtropical, it hardly seems likely that the present moorland plants could then have flourished owing to the absence of the necessary conditions, though it must be admitted that the ericetal type of vegetation may have existed for a long period, but not necessarily composed of recent species or even of the same class of plants. Only as the special conditions arose during the more temperate Pliocene ages could the moorland species have been evolved and become at all numerous. These somewhat general considerations, therefore, lead to the conclusion that the moorland plants origin-

ated in the Pliocene period, and that before this period, though species belonging to ericetal genera existed, they must be regarded as precursors of the present forms. If moors flourished during the early and mid-Tertiary periods, they must have possessed a very different facies from those of to-day.

Having thus vaguely limited the time when the moorland plants began to assume an importance in the world's vegetation, let us next endeavour to determine the place or places of their origin, and if possible, the relative ages of the different species; and on this phase of their history their geographical distribution sheds a strong light, and enables us to trace with some definiteness their past movements over the surface of the earth.

In studying the geographical distribution of either plants or animals in order to ascertain their places of origin, several important principles must be borne in mind, and as we shall require these when dealing with the fauna of the moors, it will be needful to glance at them so that the subject may be fully understood.

The most important principle is that every animal and plant has arisen in some definite area, its home or centre of origin, whence it has spread to wherever it is now found. Various means of dispersal have been followed by different species, and in the case of the plants in question, all the berry-bearing species, Bilberry, Crowberry, Cowberry, etc., are distributed by birds; the Heaths, Heather, Grasses and Sedges by the wind, their seeds being very minute. But besides these special adaptations to facilitate dispersal, there is a universal one for plants, viz.: seeds fall from the parent plant to the ground, and there germinate if there is space or the conditions favour. The young plants in their turn bear seeds which spring up in the same way; and so in this manner they extend their range inch by inch, and slowly march over the land. Doubtless this has to some extent been the case with the moorland species, but their

FIG. 33.—MAP SHOWING THE DISTRIBUTION OF THE BILBERRY (*Vaccinium myrtillus*).

special modes of dispersal have no doubt chiefly assisted in their distribution. We can imagine our moorland species radiating from their original homes to the remotest bounds of their range. Necessarily, a long time will be required for this dispersal, and roughly speaking, the wider the range the older the species ; for only after the lapse of long periods could widely-ranging forms spread over extensive areas, and pass from one continent to another, in many cases by land connections which have long been submerged. Where the range of a species is broken or discontinuous, its antiquity must also be great ; but in the present enquiry we are not concerned with such forms, all the moorland plants we shall treat of possessing continuous ranges.

Besides the distribution of any particular species we must also consider that of its allies, those of the same genus ; and since all the species of a genus have descended from some proximate or remoter ancestor, it has been argued that wherever we find the species of a genus most numerously —in other words, the headquarters of the group—such areas must be regarded as a centre of origin from which the various forms have radiated. Though this concentration of closely-allied species in definite centres is an obvious corollary of the evolution theory, it cannot be accepted without qualifications which, however, do not concern us in this place and will be treated more fully in the zoological section of this work.

We must now apply these principles to the moorland plants, taking first those which exhibit the widest range as follows :—

Bilberry (*V. myrtillus*).—Throughout the Continent ; on mountain ranges in south Europe, Siberia, Dahuria, west Asia, and north-west America (Fig. 33).

Cowberry (*V. vitis-idœa*).—Throughout Europe ; on mountain ranges in the south ; north Asia from Siberia to Kamschatka, east and west North America, Greenland.

Crowberry (*E. nigrum*).—Throughout the temperate and Arctic northern hemisphere.

Cotton Grass (*E. vaginatum*).—Throughout Europe, except Turkey; on mountains in south Europe, Siberia, west Asia, north-west Thibet, North America (Fig. 35).

Cotton Grass (*E. angustifolium*).—Similar range to its ally but also found in Greenland (Fig. 35).

Turning to the Heather and Heaths, we find they possess the following distributions :—

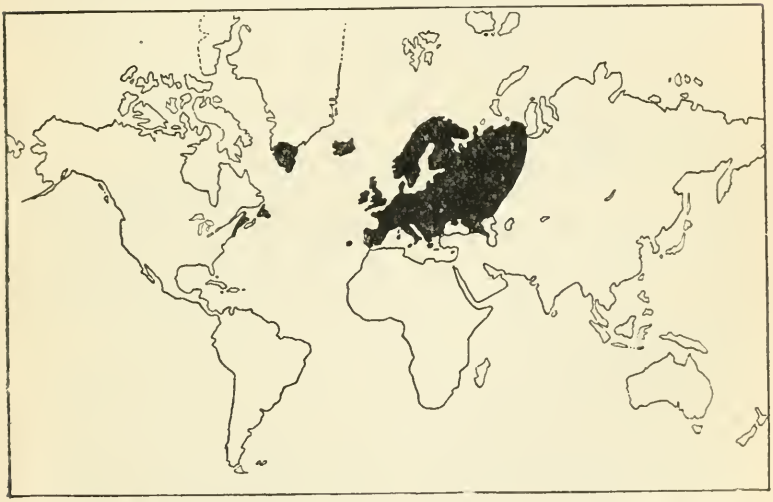


FIG. 34.—MAP SHOWING THE DISTRIBUTION OF HEATHER (*Calluna vulgaris*).

Heather (*C. vulgaris*).—Throughout Europe, west Siberia, the Azores, Greenland, Newfoundland, north United States (very rare). (Fig. 34).

Purple Bell Heath (*E. cinerea*).—Norway to Spain, and eastwards to Germany and north Italy.

Pink Bell Heath (*E. tetralix*).—North and west Europe; strictly western in south Europe, Sweden; eastwards to Russia and Transylvania, Courland and Livonia.

If it be correct that the older species have wider ranges, it follows from these facts that the Bilberry and its allies, the Crowberry and the Cotton Sedges, are of more ancient origin than either of the two Heaths or even of the Heather. The latter plant, despite its wide range, appears to have been introduced into the New World where it is extremely rare. Nevertheless, its distribution—considerably greater than that of the two Heaths—indicates an origin nearly as ancient as that of the Bilberry and Cotton Sedge groups. Another fact clearly brought out by this comparison of range is that the most widely-spread forms are more or less northern and Arctic, whereas the less widely-spread species are more or less western and southern in their distribution, and if not restricted to Europe, there attain their most vigorous development.

The decidedly northern distribution of *Vaccinium*, *Eriophorum*, and *Empetrum*, combined with the dominance of other species belonging to the same genera in the Old and New Worlds, leads to the conclusion that these familiar ericetal plants originated in the far north on a palæarctic land, perhaps now partly beneath the sea. Already we have concluded this was probably during the Pliocene period, and the supposition is confirmed when we remember that a luxuriant semi-tropical vegetation flourished in Greenland during the early Miocene. At the same epoch the North American aspect of the Swiss Miocene flora suggests a land connection between Europe and that continent. Gradually as the Pliocene approached, and the climate became cooler, the Bilberries and Cotton Sedges were evolved in adaptation to these climates, and spread eastwards and westwards throughout Europe, Asia and America. With the advent of the Glacial Period they penetrated far southwards into Europe; upon its wane they entrenched themselves on inhospitable mountains and peaty moorlands where they dominate to this day.

If a comparison of the number of widely-ranging species

with the number of less widely-ranging species shows a preponderance of the former this must be clearly due not only to their greater age, but also to their greater adaptability enabling them to thrive in a variety of climates and on poverty-stricken lands. A glance at the distribution of some other moorland species establishes this view. Among them we have the following with extensive distributions :—

Sundew (*Drosera rotundifolia*).—Europe (Arctic), Siberia, west Asia, east and west North America from the Arctic Circle to Florida.

Bog Asphodel (*Narthecium ossifragum*).—Europe north of the Alps and Pyrenees, north Asia and North America.

Club Rush (*Scirpus cæspitosa*).—Arctic and rest of Europe, Siberia, temperate and cold North America.

Sheep's Sorrel (*Rumex acetosella*).—North temperate and Arctic regions.

Brown Bent (*Agrostis canina*).—Europe (Arctic), Siberia, west Asia, Himalayas, North and South America, Australia and New Zealand.

Wavy Hair Grass (*Aira flexuosa*).—Europe, west Siberia, west Asia, North America and Terra del Fuego.

Sheep's Fescue Grass (*Festuca ovina*).—Europe, north Africa, Siberia, Himalayas, North and South America, mountains of Australia and New Zealand.

Flying Bent (*Molinia varia*).—Europe, Siberia, west Asia, north Africa.

Heath Rush (*Juncus squarrosus*).—Europe to Siberia and Greenland.

A further fact concerning these widely distributed forms is that they inhabit both the Old and New Worlds. Not only does this afford further proof of their greater age, but it may also indicate that a former land bridge existed between Europe and North America. That a land bridge formerly linked Europe with Greenland and America cannot,

I think, be doubted, when we reflect on the numerous animals and plants common to both hemispheres. Recently Dr. R. F. Scharff,* has collected all the available evidence on this matter, and when dealing with the insect life of the moors I hope to be able to adduce further facts in support of it (see page 306).

The wide distribution of the Heather gives it a claim to some antiquity, but its centre of origin was very different from that of the species we have just been discussing. Its close allies, the two Heaths, are essentially western and south-western in their distribution; and in the south of England and in Ireland, three other species occur, viz.: the Ciliated Heath (*Erica ciliaris*) found in Cornwall, Galway and Dorset; the Cornish Heath (*E. vagans*) found in Cornwall; and the Mediterranean Heath (*E. mediterranea*) found in Mayo and Galway. All three are abundant in the Mediterranean region, the two first never passing far inland. *E. ciliaris* lives round the shores of Spain, Portugal and Normandy; *E. vagans* round the shores of the Mediterranean from Spain to Greece and Turkey—it also inhabits Egypt and the west of France. *E. mediterranea* or *carnea* also flourishes in the west of France, along the Mediterranean shores and in Spain; but, unlike the others, is scattered here and there on the central ranges of European mountains from Switzerland to the Balkans. In fact, the genus is more abundant in the Mediterranean region than elsewhere on the Continent; for, besides those enumerated, such forms as *Erica arborea* and *multiflora* live in the same area. No species of Heath occurs in either North or South America, or in Asia; the genus is essentially Atlantic, being found round the shores of that ocean in Europe, and especially in

* "On the Evidences of a former Land-bridge between Northern Europe and North America," Proceedings Royal Irish Academy, Vol. XXVIII., 1909. The problem does not, however, actually come within the scope of this work. I merely mention it in passing as showing what important interest attaches to the distribution of moorland plants.

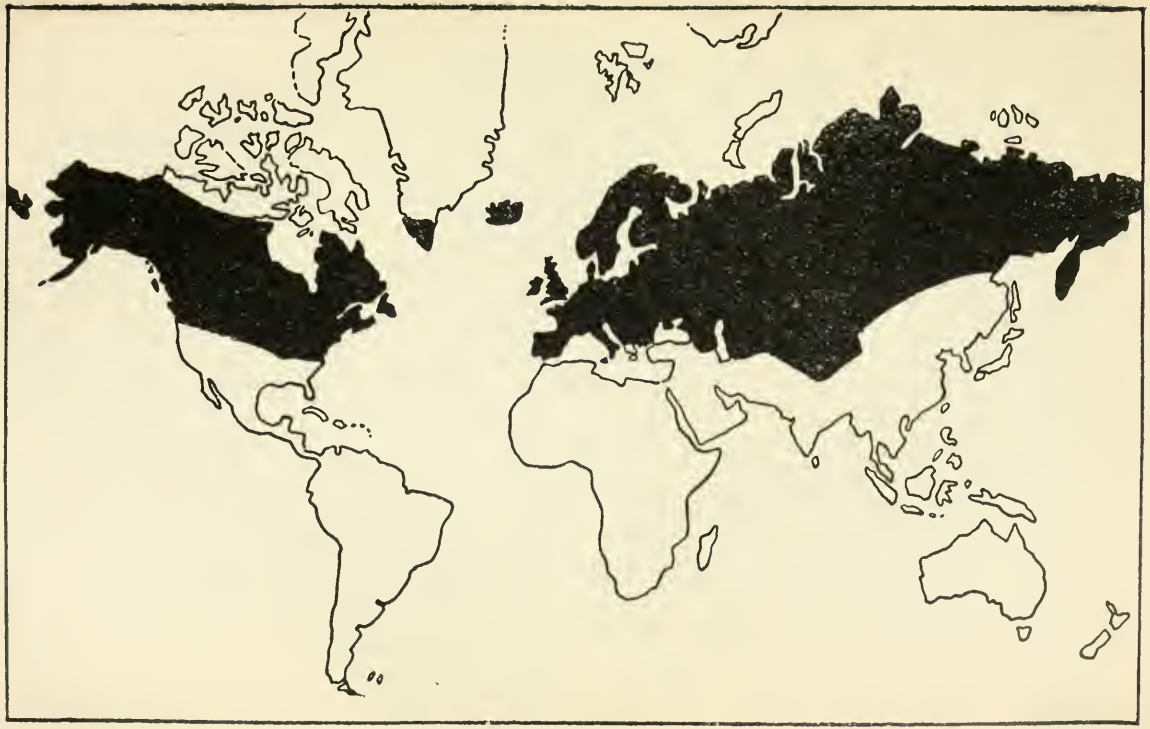


FIG. 35.—MAP SHOWING DISTRIBUTION OF COTTON GRASS (*Eriophorum vaginatum and angustifolium*).

South Africa, at the Cape, where it attains its maximum development. Whether the Heaths arose in Africa whence they migrated into Europe is doubtful ; it seems more likely that they originated far to the west of the present shores of the Atlantic, probably on ancient lands now submerged. Their absence from the New World seems to indicate a later origin than that of the Bilberry and Cotton Grass, or otherwise they might have availed themselves of the land bridge across the North Atlantic referred to.

Heather, too, must be regarded as of similar origin ; but it is a species possessing a far wider range than its allies, and has become adapted to severer climates. Its essentially western distribution—for it does not pass further eastwards than west Siberia—its great rarity in North America, and its occurrence in the Azores, are all indicative of an origin either in south-west Europe, or lands lying to the south-west of Europe, whence it has spread north and east. Probably it arose before the North Atlantic land bridge was broken, which would enable it to reach Greenland and North America. Whether Heather is a modified descendant of *Erica*, or had a common progenitor with them, would be difficult to say ; but there can be little doubt that both arose in the same part of the world towards the close of Pliocene times.

Although it thus appears likely that the chief moorland plants originated at about the same geological period, it by no means follows that they colonised suitable habitats in west Europe simultaneously. Their development in different regions precludes this, and if we take the case of the Eastern Moorlands, it is almost impossible to say which species arrived first in this district. Though erosion would by then have uncovered much of the moorland strata, they would not cover so wide an area. Only by degrees would moorlands develop as the essential edaphic and climatic conditions supervened. Slow but continuous changes of climate, the exposure by erosion of rocks poor in plant food,

and the competition of rival species, would slowly lead to the establishment of the ericetal flora, and different kinds of moors would appear, though these moors may have differed considerably from the present.

The on-coming of the Ice Age would also greatly affect the distribution of ericetal plants throughout Europe ; though, owing to their hardy character, they may have been less disturbed by this great climatic fluctuation than more delicate species, as we shall see in the next chapter. The adaptability of *Vaccinium*, *Eriophorum*, *Empetrum*, and many others to northern and Arctic climates suggests that these species may not have entered western Europe from the north until the commencement of the Ice Age. The more southern and western character of *Calluna* and *Erica* suggests that these species may have flourished in Pliocene times in warmer climates long before the advent of their northern associates and competitors.

The geological history and geographical distribution of the chief moorland plants proves then, that the moors were formed in pre-glacial times, probably towards the close of the Pliocene period. To follow this evolution through another stage we must next deal with one of the most puzzling and interesting problems they present—their relation to the Ice Age. This is such an important aspect of their history that we must devote a special chapter to it.

CHAPTER IX

THE RELATION OF THE ICE AGE TO THE MOORLAND FLORA.

THE problem stated at the end of the preceding chapter forms part of a larger problem, viz.: the relationship of the flora of the British Islands to the Ice Age; or, to put it as a question, What were the plants which inhabited this country during the Ice Age? It is quite certain that no species could exist where the land was covered by immense ice-sheets; but we have seen that a large area of North-Eastern Yorkshire remained unglaciated, and we now have to examine into the possibility of plants being able to live on this area during the period of maximum glaciation.

Unfortunately for the satisfactory solution of this problem, the only conclusive evidence, that of plant remains, is wanting, or rather their occurrence has not yet been investigated; but the data from other parts of the country prove that Arctic plants, the Dwarf Birch (*Betula nana*) in particular, flourished even as far south as in the valley of the Teign in Devonshire.* That typical Arctic plants lived upon the hills and in the dales of the ice-free region is highly probable, for we have no reason to suppose that the climate of the Ice Age was ever more rigorous than that of the Polar Regions; and the existence of glacier-lakes shows that the summer temperature was sufficiently high to melt a considerable quantity of snow and ice which would in all probability accumulate upon the moor slopes

* C. Reid, "Relation of the Present Plant Population of the British Isles to the Glacial Period," *Naturalist*, 1911, p. 373.

and summits during the winter. If we accept the conclusions of Professor Kendall, we exclude the presence of permanent masses of snow and ice upon the driftless area, for if they had persisted there could have been no glacier lakes. Doubtless in places there were accumulations ; but in the great southern dales, exposed to insolation and sheltered from the north, such masses must have melted in the summer. The existence of an abundant water-supply during the Ice Age we shall find to be one of the most important factors in determining plant survival upon the Eastern Moorlands. That the climate of the Glacial Period was extremely cold is obvious, and its severity was almost as much felt in the south of England, the English Channel, and in the Scilly Isles, as on the bleak uplands of Yorkshire. Mr. Clement Reid, who has paid special attention to this subject, states that icebergs from the Irish glaciers which debouched into the Atlantic, carried striated stones to the Scilly Isles, and that during the Ice Age these genial islands must have been surrounded by a bitterly cold ocean.* Nevertheless, despite the severity of the Ice Age, an examination of the Arctic flora of to-day and its adaptations affords some grounds for concluding that a number of ericetal, together with Arctic plants, survived the Ice Age within the driftless region of North-Eastern Yorkshire as well as in the unglaciated tracts of the south of England and elsewhere.

Professor John Phillips, in the " Rivers, Mountains and Sea-Coast of Yorkshire," was the first to hint at the possibility of a glacial survival in this county. On page 190 of the second edition (1855) of that work, after referring to the presence of Scandinavian plants in Teesdale and the Eastern Moorlands, he says :—" These same elevated districts are as remarkably deficient in land mollusca as are the mountainous tracts of Scandinavia ; they do not con-

* Op. cit., p. 375.

tain all the species of our actual fauna and flora, or even a large proportion of it, nor is it conceivable that they ever did contain them, so as to be the source from which they spread over the islands (after the Glacial Period). Therefore, although we admit that the glacial inundation did not cover all our land, and that some species may have been saved from it on the mountains, this does not the less render it necessary to suppose a second migration for the replenishing of the lower grounds with species which cannot be traced to those mountains."

As we saw in the last chapter, sufficient palæo-botanical evidence has been collected to demonstrate the existence of a pre-glacial flora very similar to the present and probably living under somewhat similar conditions. The gradual approach of the Ice Age is generally thought to have led to a gradual elimination of temperate species and to an increase of Arctic species, until with its culmination, the latter alone inhabited this country. We must not suppose from this, however, that the glacial flora consisted solely of a very few species, such as *Betula nana*, *Salix polaris*, etc., for if we examine the flora of Greenland, a country which is frequently referred to as affording an excellent picture of what Britain was like during the Ice Age, we find that this inhospitable region possesses a comparatively rich flora considering the severity of its climate. According to Warming,* 386 species of vascular plants belonging to fifty-three families live in Greenland, and according to the lists given by Rink,† there are about 230 species of mosses, 270 lichens, and twenty species of fungi. Again Spitzbergen, according to Nathorst,‡ has 192 species belonging to twenty-four families. Now amongst these plants are to be found numerous kinds, not characteristic in a general sense of the

* Om Gronlands Vegetation. Quoted by Schimper, "Plant Geography," p. 683.

† Danish Greenland.

‡ Quoted by Schimper, op. cit., p. 683.

Photo by] FIG. 36.—CHEESE STONES, BAYSDALE. [*Frank Elgee.*

FIG. 37.—BOULDER OF GRIT WITH FOSSIL CYCAD (*Williamsonia pecten*).

Polar Zone, and most of them live upon the Eastern Moorlands to-day. Of these Arctic-moorland species the following is a list :—

List of Moorland Plants inhabiting Greenland.

Heather (*Calluna vulgaris*)	Hooker
Crowberry (*Empetrum nigrum*)	Rink
Cowberry (*Vaccinium vitis-idœa*) ..	do.
Bog Whortleberry (*V. uliginosum*) ..	do.
*Cloudberry (*Rubus chamœmorus*) ..	do.
Cranberry (*Oxycoccus palustris*)	do.
Bearberry (*Arctostaphylos uva-ursi*) ..	do.
Thyme (*Thymus serpyllum*)	do.
Dwarf Cornel (*Cornus suecica*)	do.
Field Wood Rush (*Luzula multiflora*) ..	do.
Butterwort (*Pinguicula vulgaris*) ..	Kerner
Juniper (*Juniperus communis*)	Rink
Sheep's Sorrel (*Rumex acetosella*) ..	do.
Heath Rush (*Juncus squarrosus*)	Hooker
Mat Grass (*Nardus stricta*)	do.
Cotton Grass (*Eriophorum angustifolium*)	Rink
Sheep's Fescue Grass (*Festuca ovina*) ..	do.
Sedge-like Kobresia (*Kobresia caricina*) ..	Hooker
Fir Club Moss (*Lycopodium selago*) ..	Rink
Interrupted Club Moss (*Lycopodium annoticum*)	do.

To this list may be added numerous species of mosses and lichens, including such well-known moorland forms as *Sphagnum*, *Polytrichum*, Reindeer Lichens (*Cladonia*), etc., etc.

We have over eighty species of ericetal plants, including some of the most abundant, Ling, Crowberry, Cotton Grass, Mat Grass, Bog Moss, Reindeer Lichen, capable of withstanding an Arctic climate and growing side by side with

* Not found within the Eastern Moorlands, but not unknown on the Pennines.

plants peculiar to Arctic countries. If we add the ability of these moorland plants to withstand great cold to the fact that the moors were unglaciated, it is reasonable to conclude that they lived in the district throughout the Ice Age, especially in the large sheltered southern dales.

The capacity of the moorland plants to live on peaty soils and in the Arctic regions depends upon the circumstance that both conditions are those of physiological drought to which the plants are adapted as we saw in Chapter II. "A frozen soil," says Schimper,* "is quite dry to all plants, one at a temperature slightly above freezing-point is nearly dry to most plants"; and as the peaty water of moorlands is absorbed with difficulty, we understand how it comes about that the ericetal species mentioned in the foregoing lists are able to flourish not only in the Arctic regions, but many of them also on dry sand where the physical and the physiological drought coincide. Schimper also adds, "Warming was justified in comparing the vegetation of Greenland with that of the Sahara . . . Here different external factors are physiologically equivalent, and have accordingly evoked similar adaptations."† Hence many of the moorland species would be able to exist on the driftless area throughout the Ice Age on account of their adaptations. The frozen condition of the ground would render the absorption of water difficult except during the summer. By their structures also the plants would readily adjust themselves to the on-coming of the Ice Age and to its climax. As previously mentioned, water must have been abundant on the Eastern Moorlands at this period or otherwise glacier-lakes could not have existed, a further argument in support of the survival theory, for if the water or ground had remained frozen all the year round plant life would have been absolutely impossible. Another fact that has been brought to light by researches into the ecological botany

* Schimper, "Plant Geography," p. 4.
† Op. cit., p. 679.

Photo by] FIG. 38.—COAL PIT HEAP, ROSEDALE HEAD. *[Frank Elgee.*

Photo by] FIG. 39.—BOULDERS OF FOSSILIFEROUS GRIT, CASTLETON. *[Frank Elgee.*

of the Arctic regions is, that no known adaptations exist against great cold in Arctic plants, the structures of which are in relation to the shortness of the summer, dry winter winds, low temperature of the soil and air in summer, etc.*

If it be urged that the climate of the driftless area would be too severe for these plants and that denudation and snowfall would be so great that they could not flourish, the following remarks by Rink show that such circumstances need not necessarily prevent the plants from existing :—

" Temporary glaciers or accumulations of snow partly converted into solid ice and lasting for periods of a couple of years or more are frequently met with in Greenland. It may be mentioned that such a temporary glacier has been forming for several years only a few hundred feet from the European houses of Godthaab. In some years the snow is melted by the end of July ; but sometimes the warmth of the summer does not suffice to dissipate it. Not much more than a hundred feet from this spot the trader of the station has a small garden before his windows where at any-rate radishes and turnips are annually reared. . . . As the most striking contrast to these instances of perpetual snow in the lower regions must be mentioned the extra-ordinary height to which vegetation extends on the north side of a mountain chain bordering the Umansk-fjord. The author ascended it from Karsok Point in about 71 deg. 40 min. N. lat. on July 30th, 1851, during a cold and un-pleasant summer. A nearly uniform slope, only interrupted by a few terrace-shaped edges, leads from this point to a height of 5000 feet in a distance of five miles. The fore-land consisted of low rocky hills alternating with fresh green meadow-like glens exhibiting the usual shrubs such as the willow, crowberry and andromeda. . . . At a height of 2000 to 3000 feet the vegetable covering seemed decidedly thinner, the grasses and cyperaceæ which form the chief

* Schimper, op. cit., p. 671.

part of the sod disappear and are succeeded by mosses. At a height of 3000 feet the same mosses still entirely cover small boggy places adorned with blooming buttercups."* Many other facts from the same work might also be quoted showing that even close to glaciers the flora is by no means scanty, and that there is little difference in the vegetation between 60 deg. and 70 deg. N. lat., so that even if the driftless area was extremely uncongenial it may still have supported many species.

From this point of view we are glad to have the following remarks from the pen of Mr. G. W. Lamplough, F.R.S., the well-known glacialist. Speaking of the glacial geology of Spitzbergen, he says, " In this latitude the flora and fauna inhabiting the land are of the scanty Arctic type ; but under similar circumstances at lower latitudes, as for example, in Alaska and Patagonia, a dense covering of vegetation is found close up to the ice-margins. It is likely that throughout the glacial period any part of our islands that was permanently, or even temporarily, bare of ice would be tenanted by plants and animals in a similar manner. There is much probability that the Pleistocene fauna of Britain was adapted to such conditions, and was in part contemporaneous with the waxing and waning ice-sheets."†

Hitherto we have confined ourselves to ericetal plants and their glacial survival ; but many other British species, exclusive of genuine relics of the Ice Age, also thrive in Greenland. Among such forms the following may be noted on the authority of Rink :—

Common Horsetail (*Equisetum arvense*).
Wood Horsetail (*Equisetum sylvaticum*).
Beech Polypody (*Polypodium phlegopteris*).
Meadow Poa (*Poa pratensis*).
Sea Lyme Grass (*Elymus arenarius*).

* " Danish Greenland," pp. 65-7.
† Proceedings of the Yorks. Geol. Soc., 1911, p. 240.

Sorrel Dock (*Rumex acctosa*).
Mountain Cat's Ear (*Antennaria dioica*).
Dandelion (*Taraxacum palustre*).
Buttercup (*Ranunculus acris*).
Scurvy Grass (*Cochlearia officinalis*).
Willow Epilobe (*Epilobium angustifolium*).
Lady's Mantle (*Alchemilla vulgaris*).
Silver Weed (*Potentilla anserina*).
Dog Violet (*Viola canina*).
Marsh Violet (*Viola palustris*).
Stone Rubus (*Rubus saxatilis*).
Tufted Vetch (*Viccia cracca*).
Marsh Pea (*Lathyrus palustris*).

These species may be considered as of even greater importance than the true ericetal species, since they indicate that temperate plants may have become adapted to, and survived the rigorous climatic conditions of the Ice Age on the driftless area. To the list numerous cryptogamic plants could have been added, as well as species living in the icy climate of Siberia and in the neighbourhood of Alpine glaciers. Without adducing any further evidence, that given affords strong reasons for thinking the driftless area of North-Eastern Yorkshire supported some type of plant community during the Ice Age. That this flora consisted essentially of Arctic species cannot be doubted, but intermingled with them were many of the most dominant ericetal species, and probably species represented in the last list. The genus *Erica* does not seem to have survived in this district from pre-glacial times; its distribution is much too southern to suggest such a history.

We cannot say for certain what types of vegetation existed within the driftless area during the Ice Age; perhaps a vegetation resembling that of Greenland, which, according to Warming, contains a heath formation consisting of evergreen shrubs, including the ever abundant Crowberry (*E.*

nigrum), mosses and lichens. The Crowberry is one of the most characteristic plants of Greenland where it forms a kind of heath interspersed with other Arctic plants. With the Reindeer Lichen, Hair Moss, etc., it is a prominent element in the flora of the European and Asiatic tundra, and has unquestionably lived on the Eastern Moorlands since pre-glacial times.

As the Ice Age waned, the climatic conditions would begin to favour the ericetal plants intermingled with the Arctic vegetation until, ultimately most of the latter became extinct; and on the driftless area some moors would undoubtedly develop from the glacial plant communities, though where these were situated it is impossible to say. This development can only be surmised. If we follow Nehring, a tundral vegetation was dominant over Europe towards the close or shortly after the Ice Age.* The tundra moor consists of scanty peat with thin layers of Bog Moss and a few small flowering plants. Heather-clad moorland, peat moss vegetation, tundra, and Arctic associations are closely related. Not only have they many plants in common, but they owe this to their adaptations to physiological drought, one of the primary conditions of their existence.

The rarity of Arctic and high northern plants is now a remarkable feature of the Eastern Moorlands. No doubt this is primarily due to the insufficient elevation and to the over-powering competition of the temperate heath vegetation; but there are facts in regard to the distribution of the Arctic plants which do survive that appear to negative this explanation.

Previously we have referred to the south-east distribution of Sweet Gale; but if we draw another line parallel to its boundary, from Silpho Moor to Cawthorn, we find that in the moorland region thus defined, the rarest Arctic species of the uplands occur. These are:—

* Tundra und Steppen, der Jetzt und Vorzeit.

Dwarf Cornel (*Cornus suecica*).
Bearberry (*Arctostaphylos uva-ursi*).
Few Flowered Sedge (*Carex pauciflora*).
Linnæa (*Linnaea borealis*).

Rare ericetal plants found in the same region are :—

Round Leaved Wintergreen (*Pyrola rotundifolia*).
Alpine Pearlwort (*Sagina subulata*).

The Dwarf Cornel or Dogwood has, as is well-known to botanists, its sole English habitat on the north Yorkshire moors, and was formerly thought to be confined to the Hole of Horcum. In a paper in "The Naturalist" for 1907, Mr. Harold J. Burkill, M.A., F.R.G.S., points out, however, that this is not correct, the species according to him being especially numerous between the Hole of Horcum and Goathland where it flourishes amongst the Heather. Other localities for the species are Cross Cliff Banks, Staindale, and Troutsdale, all in the extreme south-eastern angle of the moors. Significant is Mr. Burkill's remark that he could not discover the species on the moors near Hawnby, for this circumstance tends to prove that these rare forms are actually restricted to the corner in question.

Out of England the Dwarf Cornel is found in the Cheviots and Scotland ; it is of frequent occurrence in northern and Arctic Europe and Asia, and extends to east and west North America.

The next plant on the list is the Bearberry, a member of the Ericaceæ, belonging to a genus which has its maximum development in north temperate America. According to Mr. Baker the Bearberry grows abundantly amongst the Heather on the moors between Levisham and Cawthorn, its only habitat on the eastern side of Yorkshire, though it is not infrequent on the Pennines.* It is essentially an Arctic plant ; Greenland, Arctic and Alpine Europe, Siberia, and

* North Yorkshire, its Botany, Geology and Climatology.

North America being its chief homes. In this country it does not extend further south than Yorkshire; but it has been recorded from the north-west of Ireland.

Carex pauciflora, according to Mr. Baker, has not been seen recently; but when formerly found, occurred in boggy places between Whitby and Pickering. This is the only Yorkshire locality for this well-known Arctic plant. *Linnæa* is another Arctic species only recorded for Yorkshire from Silpho Moor, whilst *Pyrola rotundifolia* and *Sagina subulata* are both ericetal species found on Hutton Bushel Moor, though the former grows in Halnaby Carr near Croft.

If these species are indeed the relics of the former Arctic vegetation of the uplands it seems surprising that they have not survived on the higher and colder parts of the moors. Why they should have struggled on where they are found is a fact of plant distribution difficult to understand. It has been suggested that they were conveyed to their present homes as seeds on ice-borne boulders from the north or from the Continent; but that they should all happen to be found together does not render this explanation very feasible, and moreover some of them now exist at a considerable distance from the limits of glaciation. Another reason for their occurrence may be found in the suggestion that they are the relics of a post-glacial land connection with the Continent. Most of the British flora and fauna have entered the country in post-glacial times from the Continent, and the formation of the North Sea is held to account for the absence of many species abundant in Europe. When the separation took place some species may have just reached what is now the eastern side of England, and being limited in numbers or kept down by more powerful competitors, have just managed to hold their own in isolated localities. That this may be the true explanation of the occurrence of the Dwarf Cornel, the Bearberry, the Carex, and Linnæa, is supported by the fact of their abundance on the Continent. The Bearberry forms extensive moors in north

Photo by] FIG. 30.—LOOSE HOWE, ROSEDALE HEAD. *[Frank Elgee.*

Germany, and may have traversed the site of the North Sea in post-glacial times, and entered East Yorkshire, where it has probably been unable to spread owing to the sunless climate, a powerful factor in British plant distribution. For be it noted that this south-eastern corner of the eastern moorlands is much more genial in its climate than the high moors of the watershed, and doubtless a careful investigation of the ecological botany will throw light upon the occurrence of the plants. The Arctic species must have undoubtedly formed a part of the plant life of the driftless area during the Ice Age, and their present restriction may simply be due to the complex results of competition.

There remain two plants, the history of which we have not yet considered, but which cannot be omitted in any account of heath vegetation—the Bracken and the Sweet Gale.

The Bracken fern at the present day is found over an extensive area of the earth's surface, including all the temperate zone and many tropical regions. Fossil species of Bracken date back to the Bagshot beds of Eocene age in the south of England where *Pteris eocænica* and *Bournensis* have been found. In the late Miocene a species, *Pteris oeningensis*, is considered to be the fore-runner of our familiar fern which would thus appear to have arisen in the Pliocene period.* Since the time when this genus is first known to appear in geological formations it has had ample opportunity to spread over the whole earth. Its history so far as this district is concerned may have been somewhat as follows.

Entering the district in pre-glacial times it was probably driven out during the Ice Age, but from the circumstance of its occurring in Arctic Europe, it may have survived within the driftless area, though considering the dependence of the species upon woods I do not think this at all likely. With the decline of the Ice Age, it re-entered the district

* "British Eocene Flora," Pal. Soc., 1882, p. 34, 57, 62.

with the Oak and Birch woods, and rapidly dominated the moorland slopes.

Sweet Gale whose genus, as previously mentioned, dates back to the Eocene period, has a similar history. It perhaps stands by itself, so far as ericetal plants are concerned, as a relic of a Miocene North American immigration into Europe. According to Dr. Schulz, this species came from America by an ancient land connection between that continent and Europe ; a conclusion which he arrives at from the fact that its middle European distribution possesses a south-easterly boundary, and that it is indigenous to north-east Asia.* During the Ice Age it was probably exterminated in this district ; but, from its occurrence in the cold regions of north-east Asia, I am inclined to think that it also may have survived the Ice Age upon the unglaciated region. If it did not, then it re-entered North-Eastern Yorkshire in post-glacial times.

The glacial history of the moorland plants is further complicated by the problem of inter-glacial periods. Very divergent views are entertained on this vexed question : at the one extreme we have Professor James Geikie with six European glacial and five inter-glacial periods ; Mr. Clement Reid holds an intermediate position and contends for one glacial period with a temperate interval followed by a dry cold climate, of which, however, there are only slight indications in Britain ; whilst at the other extreme is Mr. Lamplough who denies the existence of any inter-glacial periods whatsoever. When three such eminent glacialists offer such widely different opinions, it will be needless for us to do more than allude to the local aspect of the question. No evidences of inter-glacial deposits have been observed in North-Eastern Yorkshire. True it is there are two boulder clays, but these can be explained by the presence of the Teesdale and Cheviot glaciers successively occupying the low grounds during one continuous Ice Age. With the

* Quoted by Dr. Scharff in his "European Animals," p. 192.

amelioration of the climate these would retreat into their valleys; though minor fluctuations of climate might cause them to radiate on to the plains again, but perhaps not far enough to affect the Cleveland area. That such fluctuations in the disappearance of the glaciers occurred cannot be doubted, but only in the vicinity of the mountain valleys of England and Scotland can their occurrence be definitely established. The moorland flora would, therefore, be more or less affected by the recrudescence of colder intervals; and if the uplands of North-Eastern Yorkshire were surrounded by ice sheets not once only, but two or three times, the vegetation must have been influenced in a corresponding degree; but no local evidence is yet forthcoming to show that these changes have taken place.

In yet another way has the Ice Age made itself felt upon the moors. The coincidence of the drift boundary with the moor edge has already been referred to, and in the north and east the limits of glaciation have undoubtedly determined the extension of the moors in those directions. On the Lockwood Hills, on the North Cleveland watershed, and particularly near Robin Hood's Bay, Staintondale and Cloughton, cultivation practically coincides with patches of glacial sand and gravel, or extends up to the drift edge which is also the moor edge. On Hardhurst Moor, west of Hayburn Wyke, small enclosures with oats are to be seen completely surrounded by Heather, and they usually exist upon drift deposits.

The drift consisting of more heterogeneous materials produces, on the whole, better soils than occur on the higher moors, and consequently they are more amenable to reclamation. Hence to a certain extent the coincidence of the moorlands boundary with the line of glaciation is artificial for moors flourish and have flourished in the past on such deposits. Wapley, Roxby and Easington Moors occur on sand and gravel, with a tendency for the Flying Bent (*Molinia varia*) to be abundant, a feature to be seen on other glaciated

moors ; but it is not necessarily peculiar to them. In the lowlands of Cleveland, the word "moor" is frequently met with as a place-name for highly-cultivated land. In the neighbourhood of Stokesley we find Seamer Moor. That this marks the site of formerly heather-clad land is very probable, for apart from the existence of lowland moors in the Vale of York, there is the additional fact that it existed on a large spread of glacial sand.

The late Rev. E. Maule Cole has pointed out that for a distance of about twelve miles on either side of the Vale of York, thirty moors lie to the north of the great moraines at Escrick, and only four to the south. The reason for this very partial distribution he ascribes to the thinner sandy drifts of the north as compared with the argillaceous and boulder clay drifts of the south.* In the western and southern regions, however, the moorland boundary is not determined by the glacial deposits, but is due to causes to be considered later.

Having now surveyed the botanical aspects both past and present of the Eastern Moorlands we may sum up the history of the ericetal flora in the following stages :—

1.—Evolution of Bilberry, Cowberry, Cotton Grass, Crowberry, etc., in a northern land in Pliocene times, and a gradual dispersal of these species southwards with the approach of the Ice Age.

2.—Origin of Heather and Heath in south-western Europe and their dispersal north and east during the Pliocene period.

3.—The advent of the Ice Age with a survival of most of the northern species on the driftless area ; but the two Heaths, the Sweet Gale and Bracken were probably driven from the district.

4.—Post-glacial re-entrance of the two Heaths, Sweet Gale and Bracken ; development of moors from the Arctic

* The Distribution of Moorlands in the East of Yorkshire as explained by the Glacial History of the County, "Proceedings of the Yorks. Geol. Soc.," Vol. XIII., p. 400.

plant communities of the uplands and upon the bare ground.

5.—A warmer and drier climate with a decline of wet moors and the growth of trees in the slacks, gills, dales and on slopes and parts of the higher moors.

6.—An increased rainfall with an acceleration of moor formation, and a destruction of the Birch and Oak woods in the slacks and gills by the development of peat bogs.

7.—The present moors, where peat formation and destruction counterbalance one another.

Doubtless further researches will result in the discovery of other stages; but those we have enumerated are not separable by any hard and fast line. If the evolution of the moorland flora could have been witnessed the process would have appeared a very gradual one, and only after long periods would any appreciable difference in the status of the moors be detected.

CHAPTER X

MOORLAND ROCKS.

IN preceding chapters frequent reference has been made to the moorland rocks and their influence upon the vegetation. As poor siliceous soils are a *sine qua non* in determining the existence of heather-clad land, it will at once be perceived that unless the strata had been of a suitable nature the wide moors could never have been evolved. Accordingly we propose to give an account of the geology of the district, beginning in the present chapter with a description of the rocks and their mode of origin, to be followed by a discussion on the formation of the principal scenic features of the Eastern Moorlands.

Just as Heather is typical of the plant life of the moors, so is the grey sandstone boulder encrusted with lichens typical of their geology. Sometimes buried in the peat of the fat moor, at other times scattered throughout the vegetation, and in a few localities occurring in profusion, these boulders have had a surprising history, and tell us very clearly of the geographical changes which the site of the moors has undergone. They carry the origin of the moors back to a remote period when not even the slightest indication of the present vegetation existed, and when great forests of conifers and cycads flourished on the shores of an estuary and sea in which the rocks were formed.

The gritstones differ much in character according to the rocks from which they have become detached, and vary in size from a mere pebble up to huge blocks as large as a house (see Figs. 23, 36, 37, 39, and 44). In fact a complete gradation can be traced from the grain of sand to the outliers of Freeborough Hill (Fig. 57) or Blakey Topping (Fig. 47). Many of the boulders form picturesque groups that are sufficiently

distinctive to have received local names ; and occasionally large masses occur which are of special interest owing to their peculiar form or mode of origin. As an instance we may take the Cheese Stones situated on the moorland spur dividing the head waters of Baysdale (Fig. 36).

These irregularly shaped stones have upon their upper surfaces deep cavities somewhat resembling fonts, one of which can be seen in the illustration. The largest are from two to three feet in diameter, the smallest a mere depression in the rock. We may term them atmospheric pot-holes, for they precisely resemble pot-holes in the beds of rivers, but are undoubtedly due to the action of the atmosphere. Shallow hollows become filled with rain, and the wind drives the water together with small fragments of rock against the sides of the depressions, and in dry weather the gritty particles triturate the sides. An irregular wearing process is thus initiated which, in time, erodes the basins more and more deeply until large cavities are produced.

Singularly enough such fonts are of rare occurrence on the moors. Boulders can be observed with fairly deep hollows ; but hitherto no pot-holes in size equal to those of the Cheese Stones have been noticed elsewhere. The more usual forms of erosion are channels or grooves along the lines of bedding, well-illustrated in the Raven Stones above Wheeldale Gill to the south. This mode of weathering is noticeable on some of the boulders in Fig. 39.

The Cheese Stones are evidently the last fragments of a stratum of sandstone formerly covering the site of Baysdale Moors. With few exceptions (Stony Moor being one) all the moorland boulders have either been derived from some higher bed long since worn away, or from the strata on which they repose. They are not in the slightest way connected with the Ice Age, as the high moors were never glaciated.

If we project a moorland spur against the sky, we find that, as a rule, its outline is a gentle curve more or less broken by scarps or steeper slopes, as may be seen in Figs.

22, 40, and 53. In ascending such a spur we pass over the outcrop (mostly concealed by peat and vegetation) of the different strata which form the uplands of North-Eastern Yorkshire. The steep scarps correspond more or less to the outcrop of some hard bed of grit, whereas the less inclined slopes correspond to softer beds. By an examination of all the natural and artificial sections in the rocks, by piecing together the data so collected, and further, by a careful consideration of the minuter details of moorland topography, we can obtain an accurate knowledge of the stratigraphy of the moors (see geological map at end of volume).

It may be premised that the strata are nearly horizontal, and that they have been cut up into valleys, hills, and spurs, by the denuding action of the atmosphere and rivers of the district. Furthermore, the rocks have been ascertained to date back to the Mesozoic Age of the earth's history, and to belong exclusively to the Jurassic system of the same age. At that period the whole of North-Eastern Yorkshire was under water, into which diverse sediments were poured, whose consolidated remains now constitute the strata of the moorland region.

The oldest rocks covered by ericetal plants belong to the Lias, a marine formation consisting principally of shales, ironstones, and sandstones, which forms the base of the heather-clad uplands, and which crops out on the slopes and sides of the great dales. In Westerdale and on Carlton Bank, moorland plants may be seen upon the jet and alum shales of the Upper Lias, and these beds are probably the oldest in the district that support this type of vegetation.

Succeeding the Lias and resting upon it unconformably in many localities, comes that strange deposit, the Dogger; but as it plays a very small part upon the moors we may leave it, and consider those beds to which the term moorland is more strictly applicable. These rocks consist chiefly of sandstone and shale, intercalated with narrow bands of

Photo by] FIG. 41.—THE MOOR GRIT, CASTLETON QUARRIES. *[Frank Elgee.*

Photo by] FIG. 42.—KELLAWAYS ROCK, DIMMINGDALE QUARRY. *[Frank Elgee.*

ironstone and impure limestones of marine origin. The absence of marine fossils, the presence of terrestrial plants, and the occurrence of thin coal seams testify to the estuarine origin of the bulk of the moorland strata. Their nature proves that the site of the moors in Jurassic times was the estuary of some large river, probably flowing from the north-west.* In other words, the strata arose from the accumulation of sand and mud in the estuary itself. This stage in the geological history of North-Eastern Yorkshire is known as the Inferior Oolite or Bajocian, and can be divided into the following sub-stages beginning with the lowest :—

Dogger.
Lower Estuarine Series (purple on the map).
Eller Beck Bed.
Lower Estuarine Series, with coal seams at the top (purple on the map).
Grey Limestone Series (green on the map).
Upper Estuarine Series, with Moor Grit at base (green on the map).

On the coast it has been found possible to divide the Estuarine Series below the Grey Limestone, into Lower and Middle, separated by a marine band called the Millepore Bed ; but as this has not yet been traced inland, the two are there grouped together as the Lower Estuarines.

A large area of the Eastern Moorlands is covered by the Lower Estuarines, which consist principally of massive sandstones, and to a less extent of sandy shale. They occur on all the ridges dividing the dales ; on Eston, Barnaby, Hutton, Ayton, and Guisborough Moors, and on the moors of the Cleveland Hills. The Cheese Stones have been derived from this formation, which also gives rise to the bold sandstone crags capping the slopes of the great dales.

That the sea occasionally made its presence felt during

* Fox-Strangways, " Jurassic Rocks of Yorkshire," p. 391.

the deposition of the Lower Estuarines is to be inferred from a marine band, the Eller Beck Bed, which occurs towards the base of the series about 100 feet above the Dogger. This bed derives its name from Eller Beck, a tributary of the Murk Esk, and consists of flaggy sandstones and ironstone bands with marine shells. It reaches the surface in several of the northern dales, Baysdale, Glaisdale, the Murk Esk Valley, Bransdale, Farndale and elsewhere. Its chief general interest lies in the fact that the ironstone was much worked in ancient times, and old slag heaps or cinder hills are of frequent occurrence upon its outcrop. Whoever utilised this ore, whether the monks in the dales, the Romans, or the Scandinavians, they possessed an accurate knowledge of the local strata, for in the lower parts of Baysdale where the Eller Beck Bed occurs just above the stream, are several large heaps of slag on the exact outcrop of the ironstone.

The massive Lower Estuarine sandstones vary much in character and thickness; their average thickness is between 250 and 300 feet, the greatest development being attained in the northern parts of the area; in the southern Hambletons they are only 160 feet thick. They frequently die away in a most erratic fashion, well-illustrated by a peculiar topographical feature on Ingleby Moor, Hograh Moor, Castleton Rigg, Danby Rigg, and less distinctly on Glaisdale Rigg. This feature is a conspicuous hummock or long hill rising to a height of from fifty to a hundred feet above the surrounding moorland; each locality or Rigg bearing a separate hill. These detached hills are evidently the last fragments of a lenticular mass of thick sandstone which must have formerly extended from Ingleby Moor to Glaisdale Rigg, thinning out to the north and south. The latter portions of the bed have long ago been eroded away leaving the central and more massive part of the rock as a conspicuous landmark.

Towards the top of the Lower Estuarine Series there runs

Photo by] FIG. 43.—CLIFF OF KELLAWAYS ROCK, NEAR THE NEEDLE'S EYE, NEWTON DALE. [*Godfrey Bingley.*

Photo by] FIG. 44.—OUTLIER OF KELLAWAYS ROCK, HARWOOD DALE MOOR. [*Frank Elgee.*

a thin seam of inferior coal from six inches to three feet in thickness. In North Cleveland, the moor coal outcrops on the north side of Eskdale below Danby Beacon, whilst it occurs as an almost continuous bed on the moors at the heads of Glaisdale, Fryup Dale, Danby Dale, between Farndale and Esklets, and round Rosedale Head on Rosedale Common. It has also been traced on Helmsley Moor (Bog Mire Gill), Rudland Moor, Spindle Thorn, Bluewath Beck, and Collier Gill, as well as in other localities.

The mining of the moor coal used to be an important industry. Where the seams occur, numerous old pits may be found, the grey shale heaps along some gill side marking their site (Fig. 38). A little over thirty years ago at Poverty Hill, below Danby Beacon, the coal was still obtained, and as many as twelve or fourteen carts could then be seen waiting turn for loads. Shafts were sunk in some places to a depth of forty-three yards, and the seam was worked by the light of candles, and after being placed in small tubs, the coal was hauled up the shafts by means of a horse gin.

Wherever clear sections can be observed, the moor coal is seen to rest on an underclay or shale traversed by the carbonised rootlets of plants. The following is a characteristic section measured in a quarry on the east side of the Moss Swang valley near Egton Bridge :—

Shaley sandstone at base, passing into pure sandstone.
Sandy shale, becoming clayey at the top and with ferruginous vertical partitions.
Impure coal, ten inches, boundaries ill-defined.
Clayey shale, with plant rootlets, ten inches.
Very impure sandy coal, at top.

This section, properly interpreted, gives us a good idea of the physical condition of the moors during the epoch in question. The lowest beds indicate shallow water silted up with sand. Gradually vegetation flourished in the pools on a thin soil represented by the shale which

forms the underclay. The decay and accumulation of the plants produced the lower coal, this in its turn being covered with another soil in which grew the plants forming the top seam. Occasionally lenticular masses of coal exist in the Lower Estuarine sandstone, as may be seen in a quarry on Westerdale Moor, but they do not form extensive beds.

Forming a Mesozoic coalfield, the moor coal in its mode of occurrence greatly resembles that of the seams in the Carboniferous System, but an enormous interval of time separates the two, the fossil plants associated with them being entirely different. The Carboniferous flora is characterised by the luxuriant development of lycopods, equisetales, and ferns; the Bajocian vegetation is characterised by the abundance of conifers, cycads and ferns; but great as this difference is, it is not so great as that between the Bajocian and the present ericetal flora. Although the Bajocian vegetation has no direct relation to that of the moors, yet it will be well to glance at it, for it convincingly shows us that the now existing plants were at that period absolutely non-existent. Nothing can appeal with greater force to the student of the moors than to come across a block of rock embedded in peat, with Ling and Bilberry nodding over it, and bearing upon its surface a fossil frond of this ancient vegetation. Within such a small compass the whole history of the moors is compressed, from the remote past to the present day (Fig. 37).

The fossil plant most frequently met with on moorland boulders is a cycad, *Williamsonia pecten* or *gigas* (Fig. 37), a plant that must have been abundant either on the sandbanks of the Bajocian estuary, or on the adjacent shores. Associated with it are other species and genera of the same group, *Otozamites*, *Nilssonia*, *Dictyozamites* and *Zamites*. These last two genera have only within recent years been detected in the Bajocian formations of Britain. Ferns, too, are not uncommom, and include species of *Cladophlebis*, *Tæniopteris*, *Coniopteris*, *Dictyophyllum*, etc. The Gingkoales are repre-

sented among other species by *Gingko digitata*, a plant very closely related to the Maiden-hair Fern Tree (*Gingko biloba*) of China and Japan.

Another very characteristic species is a Horsetail (*Equisetites columnaris*), often found in the position of growth in the sandstones, and from which we can form a clear picture of large swamps of these plants being quietly overwhelmed and embedded in sandy shoals.

As summarised by Professor Seward, the main feature of the Yorkshire Bajocian flora is its extremely close resemblance to floras of similar age from Bornholm, India, and Japan. From the available data he draws the conclusion that the Mesozoic vegetation was not only very similar all over the world, but also throughout Jurassic times it was comparatively uniform.

The climate of Yorkshire in Bajocian times must have been decidedly warmer than it is to-day, as may be inferred from the present distribution of cycads, a conclusion still further strengthened by the fauna of the Lias and the coral reefs of the Tabular Hills.*

Above the coal-bearing strata comes the Grey Limestone Series. Typically developed on the coast and attaining a maximum thickness of ninety feet at Peak, this series is so-called because its chief member is a bed of greyish blue limestone full of marine fossils. Inland, however, the beds are thinner, thirty to fifty feet, becoming much less calcareous, and on the moorlands can generally be subdivided into three divisions, viz.: a lower series of impure limestone bands; a middle series of very coarse fossiliferous grits; and an upper series of shales with ferruginous and calcareous nodules.† It is the middle division which is of the most importance. Where the exceedingly coarse fossiliferous grit appears at the surface it forms barren and stony

* Seward, "The Jurassic Flora." Catalogue Mesozoic Plants in the British Museum.

† Fox-Strangways, "Jurassic Rocks of Yorkshire," p. 236.

moorlands, and its presence is always indicated by a steep scarp on the slopes. This rock encircles a large part of the moor between Kildale and Baysdale, and sends out a prominent tongue in the form of a steep scarp to the east. The surface is covered with boulders of all sizes and shapes, and they can be quite easily distinguished from those of any other moorland sandstone or grit for they weather out with curiously pitted and lined surfaces some of the hollows of which formerly contained fossils (Fig. 39).

The outcrop of the Grey Limestone Series on the north side of the Esk presents similar features to those displayed on Kempswithen ; the largest spread of the grit being on Wayworth and Commondale Moors, whilst along the northern slopes of Eskdale it can be traced as a comparatively narrow band as far as the Stonegate Valley. On Egton Low Moor it forms an irregular oval outcrop, but in this area it is of minor importance. Not until we reach the great watershed dividing the dales do we find the largest areas occupied by the fossiliferous grits, which here become a very important feature in the moorland topography and form a series of spurs and elevations in the highest parts of the district. A large patch lies on Stony Ridge, but the most extensive spread runs from Farndale Moor to Rosedale Common by Ralph Cross, Loose Howe, where the rise on which the Howe stands marks the outcrop (Fig. 40), Cock Heads and Glaisdale Moor, a distance of six miles, along which the outcrop varies in breadth from half-a-mile to nearly two miles on the watershed. The usual arid and barren moor is not produced by the grit, as the moors here are peaty, and consequently the direct action of the rock upon the vegetation is obscured. Outliers extend along the ridges separating Bilsdale from Bransdale, and Farndale from Rosedale. Further south, towards the foot of the Tabular Hills, the grit runs as a narrow band parallel to the escarpment.

On the west side of Bilsdale, near Hazel House, are the

singular hollows in the grit called Hell Holes (see Chapter I.). According to the Geological Survey, these have been formed by the calcareous strata below being dissolved away. At its most northerly outcrops on Eston and Whorlton Moors, the fossiliferous grit is exceedingly coarse with quartz grains the size of peas. Though elsewhere the grains are large, they rarely attain this size. The junction of the green and the purple on the map indicates the outcrop of this bed.

Immediately above the Grey Limestone Series comes the well-known Moor Grit or White Flint, the first member of the Upper Estuarine strata which also play an important part on the moorlands. Differing greatly from other moorland rocks, the White Flint is a close, compact, siliceous rock, often assuming when exposed to the weather a glassy appearance which renders it unmistakable (Fig. 41). Essentially a sandstone composed of colourless quartz grains cemented together with amorphous quartz, it differs in this respect from other moorland sandstones which, as a rule, have iron oxides as cementing substances. The Moor Grit, much used as road metal, makes the greatest spread on Egton High Moor and White Moor just to the south. North of the Esk it comes to the surface on Commondale Moor, but elsewhere it does not cover such wide areas, and occurs as a narrow band on Danby and Egton Low Moors and the moorland between Whitby and Scarborough. In the west it caps the hill of Kemspwithen at Pike Howe, and Burton Howe above Ingleby Greenhow.

The Estuarine Beds above the Moor Grit are more shaley than the series below, although near their uppermost limit a hard sandstone band can be detected. It is mainly from a botanical aspect that this set of beds assumes any importance, for it gives rise to cold wet moorlands covering a very large area. The wide moors of Sleights, Sneaton, Widow Howe, Fylingdales and Harwood Dale have for their surface rock the shales and thin sandstones of the Upper Estuarine Series, which also, as will be seen from the map,

make a considerable spread on the moors at the foot of the Tabular Hills, westwards to Osmotherley.

With the deposition of the Upper Estuarines, which attain a thickness of about 200 feet, the estuarine stage came to an end, a subsidence letting in the sea, which thenceforward covered the site of the moors until the close of the Jurassic period. The first evidence of this next stage in the geological history of the district we find in the stratum, immediately above the Upper Estuarines, the Cornbrash, which, since it is of minor importance to us here and occupies but a small space on the moors, we may pass over, merely remarking that its presence is indicated on the map by the line dividing the green (Upper Estuarines) from the pink (the Kellaways Rock).

Above the Cornbrash come the Middle Oolites, rocks which form the greater part of the Tabular and Hambleton Hills, and which are usually classified as follows :—

Callovian	Kellaways Rock.
Oxfordian	Oxford Clay.
Corallian	Lower Calcareous Grit.
	Passage Beds.
	Lower Limestone.
	Middle Calcareous Grit.
	Upper Limestone and Coral Rag.
	Upper Calcareous Grit.

So far as this work is concerned these different beds are of varying significance. Moors occur on them up to the Middle Calcareous Grit ; but the principal strata from our point of view are the Kellaways Rock and the Lower Calcareous Grit, the first forming the base, and the latter the summit of the Tabular Hills. Taking its name from Kellaways Bridge in Wiltshire, the Kellaways Rock is a soft yellowish brown and sometimes calcareous marine sandstone, covering a considerable moorland area, and varying in thickness from 70 to 110 feet, the maximum

Photo by. FIG. 45.—THE TABULAR HILLS LOOKING WEST FROM LASTINGHAM. *[Godfrey Bingley.*

The spur in the background is Boonhill; the moor rising to the right is Hutton Knoll.

being attained in Newton Dale. North of the Esk the bed is well-developed on Moorsholm, Liverton, Wapley, Easington and Roxby Moors (Fig. 42), whilst in the south it outcrops at the foot of the Tabular Hills, and is especially characteristic of the nobly precipitous cliffs of Newton Dale (Fig. 43). The nabs in the frontispiece and in Fig. 31 are formed by this stratum. In this region it reaches its widest expanse on Allerston and Lockton High Moors ; but on the western side of the same valley, as it sweeps along the base of the escarpment, the Kellaways Rock gradually lessens in breadth of outcrop, and from forming heather-clad land a mile wide on Wilden Moor, Wardle Rigg and Flamborough Rigg, at Lastingham and Gillamoor it becomes much narrower, running out in a series of bold spurs facing north. Still further to the west the rock becomes a prominent scarp or shelf at the foot of Black Hambleton and Arden Moor. The most singular feature of the Kellaways Rock is its occurrence in outlying patches on high points some distance from the main outcrop, but this may be more conveniently considered when the erosion of the moorland rocks is dealt with.

Above the southern plateau of the Kellaways Rock rises the bold, steep, and impressive escarpment of the Tabular Hills ; the course of which is clearly indicated on the map at the junction of the pink and blue colours, and the character of which is shown in Figs. 45, 46, 47, 49 and 50. Between the Lower Calcareous Grit and the Kellaways Rock is the soft Oxford Clay, consisting of fifty to seventy feet of grey sandy shale which forms the slope of the escarpment. More important as a moor-bearing stratum is the Lower Calcareous Grit, a yellow calcareous sandstone varying from 60 to 200 feet in thickness. The peculiar and striking flat-topped summits of the Tabular Hills are due to hard siliceous bands of this rock cropping out at the surface, which surface, as noted in earlier chapters, bears considerable areas of moorland, viz. : Black Hambleton and Arden Great Moor in the west ; Rievaulx Moor, Birk Nab, Boonhill Common in

the central part of the range; Levisham, Lockton Low, Allerston Low, Troutsdale, Wykeham Low, Hackness, Suffield, Seamer and Irton Moors in the east. The grit caps the great outliers of Easterside and Hawnby Hills in Ryedale, Blakey Topping and the long and singular ridge of Langdale. In the west, the same bed forms the summit of the Hambletons sweeping south to the great precipices of Whitestone Cliff and Roulston Scar.

As noted in earlier chapters, the dissolving action of the rain has removed nearly all the calcareous matter from this formation which at the surface has the appearance of a white siliceous sandstone, numerous pebbles and small boulders being dispersed amongst the Heather. On Levisham Moor, stream courses or "griffs" are of frequent occurrence in this rock. In summer they contain little or no stream; but in times of flood and in winter turgid waters roar down their narrow channels. On Arden Moor, there are numerous large circular hollows in the grit, the precise origin of which is not at all clear.

Succeeding the Lower Calcareous Grit come the Passage Beds, so-named because they form the passage between the lower horizons of the Middle Oolite and the Corallian Limestones above. North of Staindale they form the picturesque group of rocks, the Bride Stones (Fig. 48). Writing of these the Geological Survey say:—"Beyond Bickley, the Passage Beds change very much in character. They become much more gritty, and losing the calcareous aspect almost entirely, pass into a true grit, with here and there a few lenticular aggregations of fossils and calcareous bands. It is this rock which forms those remarkable blocks known as Bride Stones; which, standing up on the bleak surface of the moor above Staindale in a most peculiar manner, have a very weird appearance."*

It will be unnecessary to describe in detail the strata

* "Jurassic Rocks of Yorkshire," p. 320.

Photo by] FIG. 46.—BLACK HAMBLETON *[Frank Elgee.*

above the Passage Beds, rocks which are very calcareous, and from which we learn that the warm waters of a coral sea once covered North-Eastern Yorkshire, perhaps the most remarkable geographical condition the district has passed through. These higher beds, geologically speaking, form the more southern parts of the Tabular and Hambleton Hills, and there are a few moors occurring upon them which are worthy of attention since they demonstrate most clearly the dependence of ericetal vegetation on special kinds of rocks. These moors are the following :—

Snainton Moor on the Lower Limestone.
Rievaulx and Carlton Moors (in part) on the Lower Limestone.
Dalby Warren, Pexton Moor, Wass, Ampleforth and Sproxton Moors, Little Moor (south of Arden), on the Middle Calcareous Grit.

The occurrence of these moors is due to the arenaceous character of the strata ; limestone being either absent or very impure. It is this geological feature which explains the southward extension of the moors at Dalby Warren ; and the curious, isolated, irregular area east of Helmsley, separated from the main moors of the Hambletons by the richer, calcareous, cultivated country around Cold Kirby and Old Byland. Speaking of Dalby Warren, Mr. Fox-Strangways says :—" We find a large spread of the rock (Middle Calcareous Grit) on Dalby Moor, where it occupies nearly the whole of the higher ground, and runs out in a series of long tongues capping the ridges between the numerous valleys that intersect those hills. It here forms very dead cold land covered with Heather ; the change in vegetation from this land to the calcareous beds below being very sharp and well defined."*

The southern boundary of the moors from Rievaulx to Levisham forms a fairly regular line on the moorland map,

* " Jurassic Rocks of Yorkshire," p. 339.

and this line is rendered more remarkable when we remember that in places the boundary lies well to the south of the escarpment edge of the Tabular Hills, as at Rievaulx and Levisham ; and in others it is at their foot, especially at Hutton-le-Hole and Lastingham. Generally speaking, this boundary has been determined by the nature of the rocks, which, as soon as they become calcareous, cease to support moors, using the term in its widest local sense. The boundary is partly artificial, for man has undoubtedly reclaimed much thin heather-clad land and grassy common on the Tabular Range. It is possible for Heather moors to flourish on limestone, but usually the conditions are such as to prevent the formation of raw humus. Near Pickering there is a place called Scalla Moor, now agricultural land, which must formerly have occurred on the Upper Limestone and Coral Rag ; but whether it was clothed with Heather or was a grassy common like Spaunton Moor is quite impossible to say. If peat or raw humus can possibly form on limestones we may get moors. Thus on the Upper Limestone, near Kirby Moorside, Heather and some of its associates grow under Pine trees, and are surrounded by highly cultivated land. This feature is probably due to the formation of a thin peaty humus on the calcareous soil owing to the damper situation under the trees.

It is almost superfluous to point out that the boundary of the moors in the west, and along the escarpments of Cleveland, coincides with the extension in those directions of the Inferior Oolite rocks, the great peculiarity of the Hambletons being the heather-clad spurs of Estuarine beds which run out into the plain below the great escarpment of the Middle Oolites. A comparison of the two maps shows that Over Silton Moor, Cowesby Moor, Woolmoor, and Boltby Moor (which is a double spur) are of this nature. It may also be remarked that in north-east Cleveland, though much of the country has Bajocian strata at the surface, yet these are not covered with Heather owing to the thick-

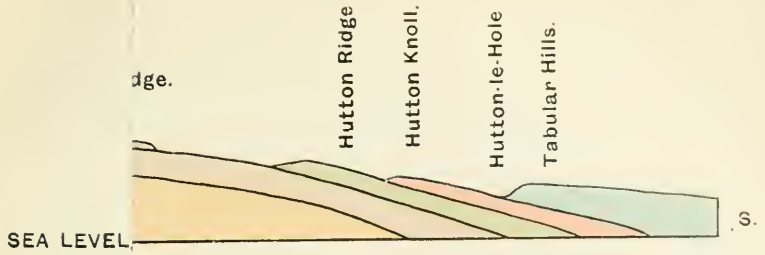
ness of the glacial deposits, a circumstance which accounts for the limited and somewhat broken character of the moors near the village of Egton.

In our description of the moorland rocks we have not attempted to describe all their peculiarities or the changes they undergo as they range across the district. Not only would this lead us too far into the domain of geology, but for our purposes it would be of little use. The chief general conclusion at which we have arrived is that by far the larger area of the Eastern Moorlands coincides with the outcrop of the Bajocian Estuarine grits, sandstones and shales, and to a less extent with the sandy strata of the Middle Oolites of the Tabular and Hambleton Hills. These rocks being poor in plant food, very siliceous, largely covered with layers of peat and raw humus, and exposed to a high rainfall, evidently form the indispensable basis for the evolution and development of heather-clad lands, a conclusion amply verified by observations made in other parts of the country.

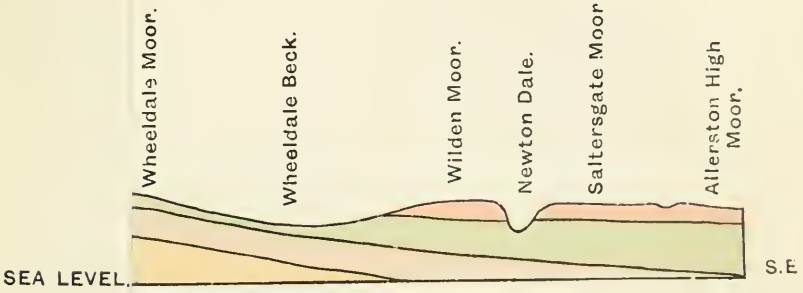
CHAPTER XI

THE EROSION OF THE MOORLAND ROCKS.

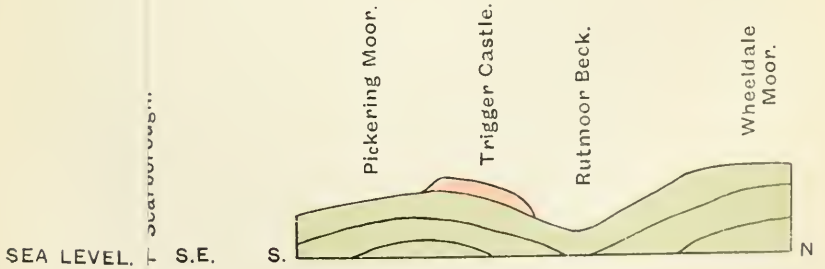
WHY are the moorland rocks so distributed over the district? Why should the moors between Sleights and May Moss lie upon the Upper Estuarine Beds, whereas towards the central and western regions the Lower Estuarines occupy the surface? Again, why should the older strata, the Bajocian, cover a wider area than younger beds—the Kellaways Rock or the Lower Calcareous Grit? The answer to these and other similar questions is to be found in a consideration of the inclination of the rocks and the erosion to which they have been subjected. The inclination or dip of the strata has been a factor of great importance not only in determining their present distribution, but also the amount of erosion they have undergone, the courses of the rivers, the origin of the dales, and the scenery of Black-a-more. In the chapter on the Mosses it was pointed out that the high central watershed from Urra Moor to Robin Hood's Bay declines in an easterly direction, and generally speaking this declination corresponds to the dip of the rocks which were uplifted after their formation, to a greater height in the west than in the east. Traced westwards along the moors of the watershed the area occupied by the successive strata becomes relatively prominent. The Kellaways Rock and Upper Estuarines prevail upon the moors round the head of the River Derwent and Newton Dale; on Wheeldale and Egton Moors, the Moor Grit covers a wider area than elsewhere; next comes the greatest spread of the Fossiliferous Grit still further westwards; and beyond this the main moorland strata are mostly of Lower Estuarine



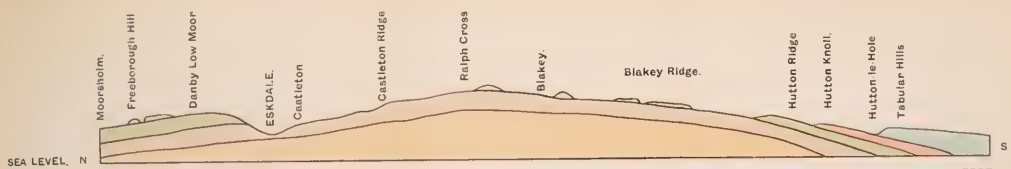
MILES=1 INCH; VERTICAL SCALE, 1/10"=200 FEET.



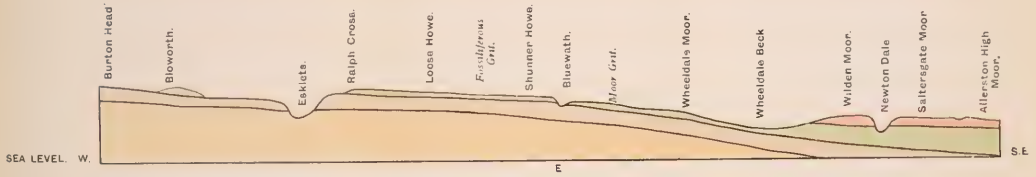
OR, AND THENCE TO SCARBOROUGH



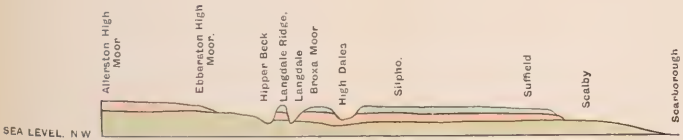
SECTION TO SHOW GEOLOGICAL STRUCTURE OF TRIGGER CASTLE (See p. 211).



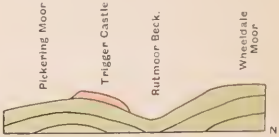
SECTION ACROSS THE MOORLAND ANTICLINAL FROM NORTH TO SOUTH. HORIZONTAL SCALE, 2 MILES=1 INCH; VERTICAL SCALE, 1/10"=200 FEET.



SECTION ALONG THE SOUTH CLEVELAND WATERSHED TO WHEELDALE MODR, AND THENCE TO SCARBOROUGH



PRECEDING SECTION CONTINUED SCALE AS BEFORE



SECTION TO SHOW GEOLOGICAL STRUCTURE OF TRIGGER CASTLE (See p 211).

COLOURS AS ON GEOLOGICAL MAP

age. The beds dip successively one beneath the other towards the east; the Lower Estuarines pass below the Grey Limestone Series, this below the Moor Grit and Upper Estuarines. (See sections).

Important as the easterly dip of the Jurassic strata is, it is not so important as their southerly dip—a dip which is general over the whole of eastern Yorkshire. If we stand upon the escarpment of the Tabular Hills, we may observe how the strata roll up like great waves from the south to the watershed. The escarpment itself forms the trough of the first wave, rising from the floor of the Vale of Pickering; from beneath this escarpment emerges a second wave, the plateau of the Kellaways Rock, whose trough is indicated by a series of bold nabs. Then comes a smaller wave caused by the outcrop of the Moor Grit and Grey Limestone; succeeded by a great arch of Lower Estuarine Beds which bend over the watershed and dip down to the Esk Valley. In reality the central watershed corresponds more or less to the summit of a dome of rocks —an anticline—on one side of which the strata dip south to the Vale of Pickering, and upon the other north to the Vale of the Esk. North of this latter valley the general southerly dip is interrupted by a synclinal trough running from west of Freeborough Hill to Ugthorpe, causing the strata to dip northwards from the northern watershed. (See sections).

To comprehend fully the bearing of these stratigraphical phenomena upon the erosion of the moorland rocks, it will be necessary to glance at the geological history of the district after the deposition of the Corallian Series. Laid down in a warm tropical sea dotted with coral reefs, these strata probably overspread a much larger area to the north than is the case at present; but towards the close of that part of the Jurassic age, the water became charged with fine mud, now forming the Kimmeridge Clay of the Vale of Pickering. What area the clay formerly covered we have no means of ascertaining, but that the Chalk, now restricted to the Wolds,

once existed over the moorland region there can be little doubt.

Towards the close of Jurassic times, there is evidence to show that the Jurassic rocks were elevated and subjected to much erosion, and it seems probable that the upheaval took place along lines that have been elevated and depressed in succeeding ages.* The truth of this post-Jurassic denudation is based on a variety of facts only one of which need be noted. At Warter, near Market Weighton, the Chalk can be seen reposing on the Lower Lias, all the intervening beds, the Middle and Upper Lias, the Bajocian, the Corallian, and Kimmeridgian, being absent; and although it is quite possible that these strata were not perhaps so well-developed in the southern area as in the northern, yet the Warter section shows clearly that the Jurassic rocks underwent extensive erosion before the Chalk was deposited. How much of the strata was removed in the moorland region cannot be known, but shortly afterwards, geologically speaking, they sank beneath the sea, and the Chalk was deposited upon them. This last fact is inferred from the character and stratigraphical features which the Chalk presents at its most northern outcrop on the south side of the Vale of Pickering. These features, according to Mr. Cowper Reed, are:—its great thickness, its general freedom from shore deposits, and its dip, which if carried northwards, would bring it over the moorland anticlinal, which had probably been formed at the close of the Oolitic Period.†

After the long Cretaceous ages had passed away, the sea floor was elevated once more, and the uplift was probably greater in the west than in the east, and gave to the rocks a general south-easterly dip. It has been thought by some geologists—chief amongst whom were Professor John Phillips and Mr. Fox-Strangways—that as the Cretaceous and Jurassic beds rose above the waves, the sea wore them down

* Fox-Strangways, op. cit., p. 410.
† "Rivers of East Yorkshire," p. 27.

Photo by FIG. 47.—BLAKEY TOPPING. [*Frank Edgee.*

to a " plain of marine denudation," the remains of which plain are to be found in the general flatness of the moorlands. Other geologists, including Professor W. M. Davis and Mr. Cowper Reed, think that sub-aerial denudation reduced the district to a base level of erosion, or peneplain, towards the close of Oligocene times, and that this peneplain was uplifted during the Miocene, and is still represented by the general level of the moorland *massif*.

If the sea has been an agent in the origination of the peneplain, we should naturally expect to find records of its presence in deposits of Tertiary age ; but it is a most remarkable fact that within the unglaciated country, superficial deposits (except peat beds) are almost entirely wanting. Whether such formations ever existed is uncertain, for denudation in succeeding geological times may have swept them away. Nevertheless there are indications that Tertiary beds may have once covered a part of the Jurassic rocks ; and these indications take the form of scattered pebbles of quartzite, flint, and occasionally other materials at present undetermined.

If Bluewath Beck—the headwaters of Wheeldale Gill —be followed to its source in the great peat moss encircling Cock Heads, and the bed of the stream be carefully examined, pebbles quite distinct from any that might have been derived from the underlying rocks (the Lower Estuarine Series below the Grey Limestone) will be noticed in some abundance. These pebbles are scattered throughout a considerable length of the stream at an elevation of 1200 to 1150 feet or slightly lower, and become much rarer down stream, until they practically disappear at some distance above Bluewath Bridge. Most of these pebbles are small, and consist of white or yellowish white quartzite ; their diameter varies from one inch and less up to five inches, the latter size having been observed in one pebble only. Besides counting over fifty quartzite pebbles within a space of a few hundred yards, I also found two or three pieces of pinkish

flint, a piece of agate, a fragment of reddish quartzite, and what appears to be a small specimen of lydian stone. Most of the pebbles are rounded, but a great number are irregular and broken. On the southern side of Wheeldale Gill, on the slopes falling towards Rutmoor Beck, similar pebbles occur, though here the elevation is less, 1000 to 850 feet. Quartzite is most numerous, and some fragments have that peculiar shape so characteristic of glaciated boulders, one side being rough and broken, the others smooth and rounded. Here also occurred a small piece of basalt, and a large pebble of pink flint. At Pike Hill Moss the pebbles will be found on the floor of the peat holes, whilst in a small stream just north of May Moss they again occur. At the time of writing I have not yet been able to examine other parts of the moors with sufficient care for further traces of these pebbles; but curiously enough, the branch of Wheeldale, behind Simon Howe, was observed to be quite destitute of them.

Whence have these pebbles been derived? Three possible explanations of their origin suggest themselves, viz. :— they are glacial; or they have been derived from higher strata now swept away; or they are the relics of post-Cretaceous deposits of Eocene age. It may be pointed out that quartzite erratics of very similar appearance are known in the drift, and that the shape of some specimens seems to indicate a glacial origin. But if the pebbles have been deposited by the ice where we now find them, it would mean an ice invasion to a height of 1200 feet at Cock Heads, and an extension of the ice margin for two or three miles from its extreme position as mapped by Professor Kendall. That Wheeldale was formerly occupied by a glacier-lake whose surface reached an altitude of 1000 feet is rendered highly probable by the discovery of the overflow at Slavey Slack, previously referred to in the chapter on the Ice Age. Hence the pebbles on the high northern slopes of Rutmoor Beck may have been derived from small bergs floating on

Photo by] FIG. 48.—ONE OF THE BRIDE STONES, STAINDALE. *[Godfrey Bingley.*

the waters of the lake. Similarly in the valley of Eller Beck near May Moss there may have been a more advanced position of the ice-front which obstructed the drainage at a greater elevation than has been supposed. But the pebbles near Cock Heads seem to negative these conclusions ; for a lake to have existed here means an ice invasion up Glaisdale far beyond the 725 foot limits of Lake Eskdale. Moreover we have to ask ourselves why quartzite is the most abundant material, and why such erratics as Shap Granite, Carboniferous Limestone, or Cheviot Porphyrite are absent ? It must nevertheless be admitted that there are various indications of a higher ice-front in this part of Cleveland, of which some of the pebbles may be the traces.

The second explanation, that they are derived from Jurassic and Cretaceous rocks formerly covering the watershed, is negatived by the fact that no quartzite bands occur in these strata. True it is that the Fossiliferous Grits often contain large quartz grains ; but then they are never so large as these pebbles, and are of a different appearance. The flints, however, stand on a different footing, for they may have been derived from the Chalk, which, as we shall presently see, certainly overlay the Oolites.

The third explanation, that they are the remains of Tertiary deposits formed during the upheaval of the rocks in post-Cretaceous times, is not unlikely. For be it noted that similar quartzite pebbles have been found very abundantly on the Wolds by Messrs. Stather and Sheppard ; the origin of these does not seem to be glacial, but appears to be due to their once having formed part of a long-lost Tertiary deposit.* So far as the moorlands are concerned it may have so happened that as the strata rose above the sea they were greatly denuded and shore deposits formed, the quartzite pebbles of which are the sole survivors.

As regards these three explanations our judgment must

* *Naturalist*, 1904.

remain suspended until further investigations have been made ; but it is not unlikely that marine denudation played a part in the formation of the peneplain as suggested by Phillips, and seemingly confirmed by the pebbles.

Here we have to recognise the fact that the present distribution of the moorland strata is due to the following causes :—(1), denudation either marine or sub-aerial in Eocene and Oligocene times, reducing the district to a base level of erosion ; (2), an uplift in Miocene times raising this base level along the moorland anticlinal ; and (3), the erosion of this mass of rocks into a series of deep valleys.

The area occupied by the different strata has been determined by their character and by the length of time during which denudation has attacked them. Taking them since the earliest post-Cretaceous elevation, one of the least resistant, and at the same time the first to be exposed, the Chalk, has been attacked for a longer period than any of the others.* Consequently it has totally vanished from the moorland area, and has been worn back to its present position on the Wolds. The Kimmeridge Clay, another soft rock, was on its exposure not only rapidly eroded, but it facilitated the erosion of the Chalk above by causing it to be undermined in rivers and streams and along inland cliffs.

The Corallian Series, harder than the Chalk, has been less exposed, and, therefore, not worn so far back, whilst the moorland grits and sandstones, the hardest rocks of the district, have been the last to be uncovered by the denuding agencies, and have consequently suffered least ; hence we find them occupying a larger area than any other member of the Jurassic system in North-Eastern Yorkshire.

Passing from these general considerations to more detailed explanations of the distribution of the moorland rocks, we must go back to the period of the Miocene uplift. What rocks occupied the surface at that time can only be con-

* The Chalk may have been thinner on the summit of the anticline. See Cowper Reed, op. cit., p. 27.

jectured. Probably the Chalk and a greater part of the Kimmeridge Clay had already disappeared from the highest moors, though as previously suggested, a thin layer of Eocene deposits here and there existed. The distribution of the Jurassic strata below the Chalk had been partly determined by the erosion they underwent in pre-Cretaceous ages, to which reference has already been made. That an uplift took place in Miocene times is extremely probable, and we may mention a fact in support of it which appears to have been overlooked ; and that is the circumstance that both the Esk and the Murk Esk traverse the line of the great Cleveland Dyke. From this it becomes patent that the Dyke is older than these two rivers, for if it were younger and had been forced up across their beds it could not have failed to produce some marked change in their courses. Hence it follows that when the rivers began to cut down from the general level of the moors, the Dyke had already been formed and was probably overlain by higher strata on which the rivers began to flow. Now from other evidence it has been concluded that the Dyke was intruded in Miocene times, a period of great volcanic activity in the west of Scotland, and with which the Dyke can be connected. The elevation of the peneplain, therefore, took place either contemporaneously with or shortly after the intrusion of the Dyke during the Miocene period.

The Miocene uplift tilted the strata in the various positions we now find them. It produced the moorland anticlinal, the syncline north of the Esk, and various minor rolls and faults ; though probably some of these stratigraphical features were accentuations of pre- and post-Cretaceous lines of disturbance. According to a well-known law of erosion, the summits of anticlines are almost invariably subjected to greater denudation than the troughs of synclines. Consequently where strata are thrown into a series of folds, those constituting the arches are worn away before those of the hollows, in which latter younger beds

are usually found; and on the moorland area this principle very largely accounts for the manner in which the various strata occur.

We have seen that as we approach the central watershed from the Tabular Hills, older and older beds occupy the surface. Formerly the Lower Calcareous Grit and the Kellaways Rock overspread the anticline; but being subjected to much erosion they have been worn back in a series of steps or waves. The familiar agencies of rain, frost, snow, springs and rivers have, in the slow lapse of ages, contributed largely to carve the present scenic features of the moorlands. Where soft shales come below harder beds, the former, being more easily eroded, cause the latter to stand out in a most prominent manner.

In this way arose the magnificent mural rampart of the Tabular Hills (Fig. 45), which, with the plateau of the Kellaways Rock at its base, sweeps along the southern edge of the moors in a bold semicircle, the arms of which at Black Hambleton (Fig. 46) in the west and near Saltersgate (Fig. 49) in the east seem as though they would enclose the central moorlands in a vast embrace. Looking eastwards from Snilesworth Moor we observe nab after nab facing northwards like a line of couchant sphinxes for ever watching the wild moorlands. From the circumstance that at Black Hambleton and Whinny Nab near Saltersgate, the escarpment extends nearly two miles further north than at Rievaulx, Birk Nab, Gillamoor and Lastingham, we must conclude that it has been subjected to less erosion at these two points. In the intermediate area the degradation has been greater, probably owing to the action of the rivers issuing from the great dales, the Seph, Hodge Beck, the Dove and the Seven. That these rivers pass through the escarpment proves conclusively that when they originated on the southern slope of the anticline after the Miocene uplift, the Lower Calcareous Grit and probably some of the true Corallian strata existed up to and beyond the watershed. For if

the great rampart had been in existence when the rivers began to flow they would inevitably have travelled along its base.*

In the course of ages, outliers have become detached from the escarpment and stand in front of it, indicative of its former extension and its future recession. Perhaps the most imposing of these outliers are those in Ryedale, the noble hills of Hawnby and Easterside, which owe their origin to the action of the rivers. Looking at the map, we find that the two hills are separated from one another by Ladhill Beck, and from the escarpment by the River Rye in the case of Hawnby Hill, and by the River Seph from Bilsdale in the case of Easterside. Uniting south of the outliers, the three rivers have, by their downward cutting, assisted by lateral atmospheric erosion, gradually carved out the two hills whose summits are remarkably narrow, and whose sides are scarred by bare rocky landslips.

South of May Moss towers the singular hill known as Blakey Topping, whose origin is clearly traceable (Fig. 47). This outlier consists of exactly the same rocks as compose the main escarpment, being capped with the Lower Grit and rising out of the broad moorland plateau of the Kellaways Rock which fringes the foot of the escarpment. Between the main range and the hill flows a stream which has carved out the valley between them ; whilst another stream parallel to the first flows on the far side of the hill. These becks unite below the outlier, clearly the last relic of the ridge once separating them, a fact further proved by the long axis of Blakey being parallel to the streams, a feature also shown by the outliers in Ryedale. The recession of the Corallian escarpment on the north-east beheaded these streams, and led to the complete isolation of the outlier which has been reduced to its present dimensions by the usual factors of erosion.

* Fox-Strangways, op. cit., p. 419.

In some places we can follow the intermediate stages leading to the formation of these singular outliers. Thus, just west of Blakey Topping, is a spur of the Tabular Hills known as Whinny Nab (the name Saltersgate crosses it on the map), and here we find that a small stream flowing at the eastern foot of the escarpment is only separated by a very narrow neck or col from the western side of the escarpment. In time this neck will be cut through by the gradual growth of the stream headwards, until the nab will form an outlier like Blakey. A further stage is represented by Coomb Hill between Arden and Hawnby, which is an outlier of Lower Calcareous Grit separated from the main outcrop by a narrow valley, the floor of which is occupied by the Kellaways Rock.

The largest of these outliers is that of Hackness and Silpho Moors, which owes its origin to the same causes, viz.: the action of the rivers on all sides. The narrow and lengthy ridge of Langdale has resulted from the erosion of Hipper Beck on the western side, and the River Derwent on the eastern side. The great gorge through which the latter river now travels was formed during the Ice Age (see Chapter VIII.). It therefore follows that the outlier of Langdale *did not exist in pre-glacial times* in this respect differing from every other outlier of the Tabular Hills, which arose long before the advent of the Glacial Period.

Beyond Saltersgate and Whinny Nab, the Tabular Hills form another embayment at Cross-cliff, sweeping north along the remarkable ridge of Langdale. We find that this recess coincides with the presence of three rivers, Grain Beck, Stockdale Beck, and Hipper Beck, which flow through it and join the Derwent at Langdale End. Grain Beck, after rising in May Moss and flowing south to the foot of the escarpment, then runs along its base as Black Beck, and this must undoubtedly have conduced to the recession of the Tabular Hills at this point.

Owing to the Moor Grit and the Fossiliferous Grit not

Photo by FIG. 49.—WHINNY NAB, A SPUR OF THE TABULAR HILLS, NEAR SALTERSGATE. *[Frank Elgee.*

Photo by FIG. 50.—EASTERN SLOPES OF THE HOLE OF HORCUM, LOOKING SOUTH. *[Frank Elgee.*

being underlain by any considerable thickness of soft shales, they only form a comparatively inconspicuous scarp on the moors between Bilsdale and Rosedale. Moreover, being excessively hard, they have resisted denudation more successfully, and consequently occur as small outliers on many parts of the moors, as on Burton Head, at Bloworth Crossing, between Bilsdale and Bransdale, and elsewhere.

A journey along the road from Hutton-le-Hole to Rosedale affords an excellent opportunity for observing the stratigraphical features of the moors at the base of the Tabular Hills. Descending the steep slope of the escarpment from Yoadwath to Hutton village, and going along the road at its foot, we pass from a warm rich land to a cold and poor one. On our left rises the slope of Hutton Knoll, corresponding to the outcrop of the Kellaways Rock, whilst away to the east lies Spaunton Knoll composed of the same bed. A glance at the scarp of Spaunton Knoll and the Tabular escarpment to the south shows that it is actually higher than the latter, a feature also exhibited by Askew Rigg, Lastingham Knoll and Hutton Knoll, and first pointed out by Mr. Fox-Strangways. On reaching Loskey Bridge over Loskey Beck we find that we are on the top beds of the Upper Estuarine Series below the Cornbrash, and a good section is exposed below the Knoll on the eastern side of the stream. Still ascending the road we leave the scarp of the Kellaways Rock on our right and reach Spindle Thorn, the ridge of Upper Estuarine rocks between Loskey Beck and Barker Slack. About a mile from Spaunton Knoll another scarp appears above the level of the moors, that of the Moor Grit with the Fossiliferous Grit below. Looking east we see a prominent tongue of the same strata running northwards to Ana Cross which stands on the very edge of the scarp. Similar features occur nearly everywhere at the base of the Tabular Hills, and all indicate in the clearest possible manner the relation of the dip of the rocks to the

surface topography, and to the courses of the streams flowing southwards. (See sections).

That younger strata are preserved in the troughs of synclines is apparent when we recall the succession of dominant strata as we proceed eastwards from Botton Head. The greater elevation at the latter point has caused greater erosion to take place there, so that the Lower Estuarines occupy the surface. As the anticline dips eastwards, younger and younger beds come to prevail upon the moors until the wide Upper Estuarine Series of Sleights Moor is reached, and this district, being the lower part of the dip, has been comparatively less eroded.

In North Cleveland we observe similar phenomena. The Lower Estuarine Series dominates on Great Ayton, Newton and Guisborough Moors, and is followed by a large spread of Upper Estuarine Beds at lower levels on Stanghow and Danby Low Moors. Here, however, we meet with a large outlier of Kellaways Rock lying in a synclinal trough, and coming to the surface on Moorsholm, Girrick, Easington, Wapley, and Lealholm Moors, a striking illustration of the preservation of younger beds in such depressions. The outcrop of the Kellaways Rock is finely displayed on these moors. Danby Beacon, as seen from the west, exhibits a flat-topped boss, a small outlier of the Kellaways Rock. To the north is a shallow hollow of Upper Estuarine Beds followed by another slight rise to another flat-topped boss, the Kellaways Rock again ; and on Danby Low Moor a marked ridge—Elm Ledge—indicates the southern edge of the same formation. On Moorsholm Moor it occurs in large patches on slopes ; and also caps the summit of Freebrough Hill, east of which it has been faulted down against the Upper Estuarines of Stanghow Moor. The distant slopes beyond the head of Ewe Crag Slack in Fig. 22 consist of this bed.

The Kellaways Rock shows very clearly the relationship of synclines to outliers, though some of these latter are

Photo by] FIG. 51.—WINTER GILL, GLAISDALE. *[Frank Elgee.*

Photo by] FIG. 52.—BAYSDALE BELOW HOB HOLL. *[Frank Elgee.*

partially due to its greater durability. On Cropton Moor there are two patches of the rock at Keldy Grain ; there is another in the form of a prominent hill at Trigger Castle on Pickering Moor ; a fourth occurs on Simon Howe above Goathland. East of the Murk Esk there are four, Stony Rigg between Woof Howe Grain and the River Derwent ; a second on Lownorth Moor between the Derwent and Bloody Beck ; a very small one above Harwood Dale shown in the photograph, (Fig. 44), and a larger one at Blea Hill Rigg on the moors at the head of Iburndale where the Cleveland Dyke terminates. The outliers at Trigger Castle and Blea Hill Rigg lie in synclinal troughs, but this does not mean that they exist in actual depressions. Far from it. Blea Hill Rigg, lying between Blea Hill Beck and Jugger Howe Dale, forms, as its name indicates, a distinct moorland spur on either side of which the rocks dip inwards ; the slope and elevation of the outlier being due to the usual factors of erosion. And similarly with Trigger Castle, where, however, one side of the syncline has been severed by Rutmoor Beck and swept away. Looking at the hill from the east we see that the dip of the summit is to the north, whereas the rocks on the other side of the stream possess the usual southerly dip of the rocks south of the watershed. (See section).

The outliers of this rock on Lownorth Moor are the last relics of a continuous sheet reduced to its present fragmentary condition by the action of the rivers and the atmosphere on the slopes. The illustration in Fig. 44 shows the neat character of these singular outliers which look like huge slabs laid horizontally upon the surface of the moors. At one time in their history, the little bosses of Kellaways Rock would be capped with the Lower Calcareous Grit, and the moors would then have appeared even more picturesque than they do to-day, since all the outliers would be much higher, closely resembling Blakey Topping and the hills in the valley of the Rye. The occurrence of these

outliers not only proves the former continuous extension of the Kellaways Rock over the moorland area, and by parity of reasoning, the former extension of the Corallian rocks and the Chalk, but it naturally suggests that some fragments of higher strata may yet be detected upon the Estuarine Series. As the younger and higher beds were gradually worn away, it may have so happened that harder fragments so obstinately resisted erosion as to have slowly settled down upon the lower beds though all traces of their parent rock had vanished. This has occurred in other parts of the country, and it may be possible that some of the pebbles of flint referred to at the beginning of the chapter, are survivors from that remote time when the Chalk with its snowy mantle covered the site of the black and peaty wastes of North-Eastern Yorkshire.

CHAPTER XII

THE ORIGIN OF THE DALES.

THE present distribution of the rocks has been produced by the action of atmospheric and river erosion upon the varied strata of the moors, and it will readily be seen that these causes have largely assisted in modifying the character of the moorland vegetation. By exposing shaley rocks in one part, sandstone rocks in another, and limestones in a third, these agencies have enabled adapted types of vegetation to colonise the ground; but there is still another influence that has led to the distribution of plants on the Eastern Moorlands—the great dales with their tributary gills and ravines. For these beautiful valleys, perhaps the most characteristic feature of Cleveland scenery, cut up the Jurassic tableland in a surprising way, leaving wedges and spurs of heather-clad land projecting from the watersheds. Their streams have largely aided in the carrying away of the moorland rocks and in giving rise to moorland slopes. Moreover, many of the dales may have acted as lines of immigration for plants and animals, after the close of the Ice Age.

The same factors which led to the erosion of the rocks also led to the origin of the dales. In the words of Sir Archibald Geikie, "in no part of England is the relation of the surface topography to the nature of the underlying rocks more instructively displayed than in this district; the strata being nearly horizontal and little disturbed by dislocations, the valleys radiating from the tableland can be traced out as the results of erosion with a precision and completeness unattainable in other parts of the country where the geological structure is less simple."

Writing in 1876, Messrs. Tate and Blake considered that the initial stages of the dales were lines of fracture produced by the uplift along the anticlinal, that denudation worked along the cracks that were thus formed, and that the heads of some of the dales are lines of fracture still, notably Baysdale, Bransdale, and Tripsdale (Bilsdale East).* It is not, however, necessary to invoke the aid of fractures to account for the courses of the streams and the valleys in which they flow. Mr. Fox-Strangways was perhaps the first to point out that the dales have simply arisen on the slope of the rocks after their upheaval, no cracks being produced so far as we at present know ; minor irregularities would no doubt determine the somewhat variable courses of the streams, as may be witnessed on any clayey or sandy slope after rain.†

Mr. F. R. Cowper Reed has ably discussed the history of the dale streams in his " Geological History of the Rivers of East Yorkshire," which he divides into the following six stages or cycles :—

First Cycle.—Initiation of the river system on a land surface after the Cretaceous uplift. These rivers flowed from east to west, and are now represented by the western dales of Swaledale, etc. The course of the Esk and the Vale of Pickering are probably relics of this stage.

Second Cycle.—Elevation of the base level of erosion during the Miocene period ; origination of the moorland anticlinal . During this stage and to the close of the Pliocene period the sculpture of the dales took place.

Third Cycle.—Period of temporary subsidence at close of Pliocene drowning the lower reaches of the streams; but this stage is of no importance to us here.

* " The Yorkshire Lias," p. 195.

† " Jurassic Rocks of Yorkshire " ; also " Valleys of North-East Yorkshire and their Mode of Formation," Transactions Leicester Phil. Soc., 1894.

Fourth Cycle.—The Ice Age and its effects upon the river system in post-glacial times. This stage we have already dealt with, so far as it concerns the moors.

Fifth and sixth Cycles are of very minor significance.

Though in these pages we are not so much concerned with the history of the rivers as with the effects they have wrought upon the rocks and scenery of the moors, yet we have thought it advisable to summarise Mr. Reed's researches for they are of invaluable assistance in ascertaining the time when the dales originated.

The dip of the rocks has been the main cause in determining the direction and course of the dales, whilst erosion by the streams and atmospheric agencies have excavated them. The easterly dip of the post-Cretaceous land surface gave rise to the direction of the valleys of the Esk and Kildale ; that of the northern and southern slopes of the anticlinal to the dales radiating from the central watershed. As Mr. Cowper Reed has shown, some streams arose after the first post-Cretaceous uplift, the Esk probably being one. On the formation of the peneplain and its Miocene upheaval the rivers received a new lease of life ; they began to cut down into the Jurassic tableland, and thus the first steps in the origin of the dales were taken. The southern dip initiated Ryedale, Bilsdale, Bransdale, Farndale and Rosedale ; the northern dip initiated Baysdale, Westerdale, Danby Dale, Fryup Dales, Glaisdale, Egton Grange, the Murk Esk Valley and Iburndale.

It is probable that the dale-river system commenced its erosive work, after the Miocene uplift, on the rocks of the Corallian Series ; a fact proved by the circumstance already noted, that the southern streams invariably break through the escarpment of the Tabular Hills. It would take some ages for these rocks to be penetrated, and fortunately in the Hole of Horcum and other valleys on the Tabular Hills, we have instances of what the southern dales

were probably like at an early period of their existence. Lying on the moors of the Tabular Hills above Saltersgate, the Hole of Horcum is a large basin-shaped hollow two or three hundred feet deep and quite half-a-mile in length (Fig. 50). Round the summit runs the Lower Calcareous Grit, along its slopes is the Oxford Clay, and forming its floor is the Kellaways Rock. Where Levisham Beck, which rises in the Hole, escapes to the south, the valley contracts very markedly, and the remaining portion of the course of the stream lies in a narrow gorge falling into Newton Dale.

To explain the origin of this remarkable feature of moorland topography is simple, for here, as in every other case of erosion in North-Eastern Yorkshire, a solution is to be found in the relation of the stream to the character and dip of the rocks. In the Hole of Horcum, Levisham Beck has cut down to the Kellaways Rock through the Lower Calcareous Grit and Oxford Clay, whereas in the gorge-like part of its course the stream flows over the grit itself and has the Passage Beds and Lower Limestone constituting its slopes. In these facts we have the clue to its origin. Penetrating the grit at its head, the beck upon reaching the Oxford Clay would be assisted in its eroding power by springs thrown out at the junction of the clay with the grit, and this would cause denudation on the slopes to proceed more rapidly. This cause would be accelerated by a further cause, the soft nature of the Oxford Clay, which, being readily eroded, would also yield along lines of joint, and lead to the collapse of the superincumbent rocks. Thus, on all sides, the Hole would gradually be enlarged until it attained its present dimensions. Downstream, however, the Calcareous Grit is brought to the bed of the river by the southerly dip, and is there capped by the hard Passage Beds and Lower Limestone. Consequently, although in the gorge the stream has penetrated the same thickness of rock as in the Hole of Horcum, it has not yet reached the Oxford Clay. Erosion, therefore, would proceed at a much slower rate, for

Photo by] FIG. 53.—GRAIN BECK, BAYSDALE, LOOKING NORTH. *[Frank Elgee.*

though the downward cutting power of the stream is even greater, owing to the augmented volume of water, the action of springs on the valley sides would be practically very small, the result being that the slopes would not be worn away so rapidly as in the Hole of Horcum.

This type of valley is really not uncommon on the moorlands, as we shall presently see. The valleys of the Tabular Hills, however, are generally narrow and gorge-like, and even where their floor and slopes consist of the Oxford Clay they are never as wide as the great dales carved out of the softer and thicker beds of the Lias. A comparison of the character of the valleys made by the rivers out of Bransdale, Farndale and Rosedale, where these flow over the Lias in their upper reaches and over the Corallian Rocks in their lower reaches, proves this. Moreover, a glance at the map shows that the dale-streams, where they cross the Tabular Hills, traverse wider valleys when the Oxford Clay forms their floor, than when the Corallian Rocks lower down stream outcrop on the floors and sides. This is in perfect consonance with what we have just seen is characteristic of the Hole of Horcum. Another peculiarity of the valleys of the Tabular Hills is their innumerable tributaries forming branch dales of great complexity. Those on the Hackness outlier are a noteworthy instance and were compared to a stag's horn by the Father of English geology, William Smith.*

In this respect Thornton Dale is more remarkable. The dale itself runs due north and south along the dip of the Middle Oolites; its head branch being Staindale which flows east and west. Between Staindale and Pexton Moor (see map), Thornton Dale on the west has no tributary valleys falling into it; but on the eastern side there are no less than six (not including Staindale), viz.: Sieve Dale, Snever Dale, Low Dalby Dale, Flax Dale, Heck Dale, and

* "Memoir on the Stratification of the Hackness Hills." Published for the first time in the "Jurassic Rocks of Yorkshire."

Sand Dale, the latter being bifurcated at its head. Except Sand Dale all these valleys are practically streamless, and whatever waters they once contained flowed over the Lower Calcareous Grit. Mr. Cowper Reed would attribute them to the complicated outcrops of the strata induced by a synclinal fold running across Allerston Low Moor to Lockton and Levisham. He is further of the opinion that they were formed towards the end of his second cycle of river development, that is to say, towards the end of the Pliocene period, after all the main features of the surface had been developed.* However this may be, the most mysterious aspect of these tributaries is their number and the limited size of the gathering grounds or watershed, an aspect that is rendered even more mysterious by the reflection that eastwards of Sand Dale, between that valley and the village of East Ayton, the following valleys also rise on the same watershed, and flow down the slopes of the Corallian Rocks and debouch into the Vale of Pickering, viz. : Given Dale, Ox Dale, Keck Dale, Netherby Dale, Wydale, Brompton Dale, Sawdon Dale, Bee Dale, and Yedman Dale. Altogether and including Staindale, there are no less than seventeen valleys draining a watershed that is about eight miles in length and extremely narrow ; the distance between the head of Givendale and Troutsdale is barely half-a-mile. As many of them are dry, it is likely that some of the streams have disappeared underground, so often the case with rivers on limestone rocks, as may be seen where those from the great dales cross the Corallian strata. But why should Thornton Dale have six lateral branches on one side only, and that side just a little over three miles long ? Some factor seems to have operated here which we have not yet been able to discover. Doubtless a more careful examination of the ground will reveal this factor ; but this part of the moors is certainly unique, the nearest approach to it

* Op. cit., p. 81-82.

Photo by] FIG. 54.—THE HOWE, CASTLETON. *[Frank Elgee.*

being perhaps the branches of the Rye between Sproxton and Old Byland.

Returning once more to a consideration of the great dales, the probability is that the erosive work began on Corallian or even higher strata during the Miocene uplift; and doubtless the upper reaches of the streams then resembled those sections of their courses where they now cut through the Tabular Hills, whilst in places there would be features as seen to-day in the Hole of Horcum.

In the course of ages, the Corallian and Callovian strata would be penetrated, removed from the arch of the anticlinal, and the escarpment of the Tabular Hills formed. The streams on both sides of the watershed would then begin to excavate the hard rocks of the Inferior Oolite, a stage still represented by the head-waters of many of the dales. Here we observe shallow gathering grounds through the lengths of which meander the tiny streams. These aspects of a dale can be well seen at the source of Grain Beck in Baysdale and at the two heads of Tripsdale.

When the Upper Lias is reached, however, the downward cutting power of the streams is facilitated by the soft shaley rocks of this formation, and the appearance of the dale changes. Two slopes can now be detected in the valley sides—a steep slope rising from the stream and corresponding to the Alum Shale outcrop, and a gentle shelving slope rising to the flat moor top, and marking the outcrop of the Oolite. Such ravines form the most charming and picturesque haunts upon the moors. Bubbling over blocks of grit and sandstone flows the moorland stream, the steep slopes are clothed with gnarled Birch and Oaks mottled with grey lichens, craggy cliffs cap the steep and sometimes bare shale screes, and tongues and feelers of dark Ling thrust downwards over the grey heaps of debris. Among many such valleys may be named Hograh, Grain Beck (Fig. 53), Clough Gill, Winter Gill (Fig. 51), and Tripsdale.

Still further downstream we enter the dale properly so-

called. Here the increased volume of water and the softer Liassic rocks have caused the valleys to be eroded much more widely. In most of the dales the Lower Lias occupies the floor ; but in Glaisdale this consists of the Middle Lias, whilst in Baysdale and Egton Grange the Upper Lias outcrops. Tate and Blake, in their great work on the " Yorkshire Lias," long ago pointed out that the prevalent easterly dip causes landslips more frequently to happen on the western side of the dales than on the eastern, owing to the rocks more readily giving way along lines of joint. In Danby Dale, near the solitary cottage known as St. Helena, a long ledge runs along the western side of the valley, where extensive slips of rock from the edge of Castleton Rigg have taken place. Large heaps of debris are scattered along the outside margin of the ledge, on the inside of which peat has accumulated, and from which our picture of the Cotton Grass in fruit was obtained. More striking are the immense slips at Great Fryup head on the western slope, where an irregular confusion of huge mounds and deep depressions, caused by large landslips from the cliffs above, is known as Fryup Hills. The material that thus crashes down the slopes at long intervals is attacked by atmospheric erosive agents and bit by bit carried away by the rain to lower levels, as may be seen after every shower, until the fragments ultimately reach the stream and are thence borne to the sea.

At the summit of the dales we find a bold cliff of sandstone followed by a slope answering to the Upper Lias shales ; though the latter in places is much obscured by fallen debris from the crags above. Next comes a much steeper and more conspicuous scarp corresponding to the hard beds of ironstone and sandstone of the Middle Lias, to be finally succeeded by the slopes of the lowermost shales merging into the floor of the dale. Let us now examine some peculiarities of these interesting valleys.

Farndale and Rosedale have a decided trend to the south-east, apparently due to the combined effects of the two dip

Photo by] FIG. 55.—BLOODY BECK, NEAR ITS JUNCTION WITH JUGGER HOWE DALE, LOOKING EAST. [*Frank Elgee*

slopes—that to the south from the anticline, and that of the anticline itself towards the east. The southern dip brings the Inferior Oolite down to stream level in the southern dales, for a mile or more before they break through the Tabular Hills. Here the valleys become much narrower and shallower than where they traverse the Lias, and in fact we have a repetition of the same features which make the Hole of Horcum so remarkable, namely the valleys are wider in their upper than in their lower parts. Some of the northern dales possess similar characteristics. The two Fryups, Glaisdale and Egton Grange, trend north-east in accordance with the dips; but the most striking instance is Baysdale, which, after running due northwards, suddenly turns eastwards and joins Westerdale near Castleton. Naturally one would have thought that the valley would continue northwards and coalesce with the Esk-Kildale valley, for this would have been in unison with the northern dip. Evidently, however, the eastern inclination of the rocks, joined with some irregularity of the original surface, has determined the eastern direction of its lower reaches. On the south side of this part of the dale, and crossing the road from Hob Hole to Westerdale, is a curious shallow dry valley, which, running eastwards, finally curves round and joins the main dale at a high level. Probably this singular little channel may be the relic of a former course of the stream when it flowed at a higher level, and before it had cut deep into the Jurassic platform. At the junction of Baysdale with Westerdale at Dibble Bridge, we find two parallel north and south faults, trough faults as they are termed, which let down the Oolite between them, and also between which flows the Esk from Westerdale. The Baysdale stream cuts across the westernmost fault, a feature that proves nothing as to the relative ages of either the one or the other, for on the formation of the fault *after* the stream had commenced to flow, it would only lower the rocks at its exit. If the fault originated *before* the stream, it would

either be covered with higher beds, through which the stream would cut down across the fault, or the water would flow over a fault scarp as before. By bringing down the hard sandstones of the Inferior Oolite at the mouth of Westerdale, these two faults have caused the Esk to flow through an extremely narrow exit as compared with the great width of Westerdale where it traverses the softer rocks of the Lias. Baysdale Beck, too, in the lower eastern part of its course where it flows through the hard grits is also much narrower (Fig. 52). From these facts it becomes obvious that the type of valley represented by the Hole of Horcum is one that is characteristic of the Eastern Moorlands, though at first sight we might be inclined to think the famous " Hole " unique.

The source of the Esk, Esklets at Westerdale Head, is in many respects interesting, being a large shallow basin-shaped hollow with a narrow exit, this exit expanding into the main dale (see map). Somewhat similar though much smaller features are exhibited by a parallel branch valley, Clough Gill. The explanation given of the Hole of Horcum accounts for these instances also ; and at one period the heads and upper parts of all the Liassic valleys must have been like Eskletts or the Hole. The dip of the hard Bajocian rocks brings them in the lower reaches to stream level ; but, owing to the increased volume of water, the thickness of the Lias shales, the larger gathering grounds, and the more powerful affluents, this aspect has been very largely lost in many instances.

We have traces of it in Danby Dale, for where the stream emerges between Castleton village and the Howe Hill into Eskdale, it is narrow because of the presence of the Oolite, whereas the two Fryups, Glaisdale, and Egton Grange, have wide mouths owing to the Lias having been penetrated by their respective streams at the junctions. But the great peculiarity of Danby Dale at its " end," to use the local word for the coalescence of the dales with the Esk valley, is the

celebrated Howe Hill, previously referred to as being clothed with a fine example of grass moor (Fig. 54). In this respect the dale is unique, for no similar prominent hill occurs where the other dales debouch. We are enabled to trace its origin from the circumstance that in other parts of the district we possess all the intermediate stages leading to the production of such a hill. Let us follow these stages and see how the Howe Hill has arisen.

Buscoe Beck at the end of Glaisdale Ridge supplies us with the first stage. It forms a shallow valley—Glaisdale Swangs—rising towards the Glaisdale side where there is a distinct col in the level of the ridge. From this it follows that the high land on the eastern side of Buscoe Beck will become separated from the Ridge by the gradual lowering of the col and cutting back of Buscoe Beck.

The process of separation is seen in a further stage of development in the relations of the two Fryups. The two dales are connected by a remarkable pass which has not yet been eroded down to the valley level. Evidently the ridge dividing the two dales formerly extended across this pass, where there would at first be a low col, as at Buscoe Beck. The gap would be gradually deepened by various erosive agents until the pass was formed. Applying these data to the Howe we at once perceive that this hill simply represents a more advanced stage of the same process of erosion. That the Howe Hill formerly extended up Danby Dale somewhat after the manner of the ridge between the Fryups is certain, since a distinct platform caused by the hard beds of the Middle Lias runs from below the Howe towards Danby Church and thence into the eastern side of the dale. On the same side of the Howe is a small stream, with its lower parts where it falls into the Esk choked with gravel, obscuring the actual depth of the valley. Commencing as a small runlet on the end of Danby Rigg, the waters of this stream gradually cut back and produced a col on the valley wall overlooking Danby Dale. This in the course of ages

was slowly worn down, and backwards, until the present Howe Hill originated. An almost identical outlier occurs in the lower parts of Bransdale where a long wedge of the Inferior Oolite has been detached from the eastern side of the valley, by the action of a small stream flowing into the main dale. Unlike the Howe it is entirely surrounded by Lias.

In the gap between the two Fryups is a conspicuous land form known as the Round Hill consisting entirely of Lias rocks and with no capping of hard sandstone, though this must once have been the case. In accounting for this hill we shall have an opportunity of explaining a very similar one in Rosedale which affords us a key to the problem. On its eastern side Rosedale has a large tributary gill debouching into it—Northdale—the lower parts of which are separated from the main valley by a high and very narrow ridge of moorland capped with the massive Estuarine sandstones (see map and Fig. 56). Beyond the end of this ridge is a deep gap penetrating to the Middle Lias, and bounded on the south by a prominent round hill of Upper Lias above the village, and precisely agreeing in every particular with the Round Hill in Fryup. A closer inspection of the high narrow ridge reveals the fact that the summit sandstone, at its termination, is wider than the same rock half-a-mile further to the north where it is less than 150 yards across. Now erosion working upon this neck of rock will wear away the narrow part long before the wider end of the ridge, which will consequently form in time an outlier of Oolite surrounded by Lias. Erosion still continuing, the neck now composed of the softer Lias, will be worn into a pass or col by the time the outlier loses its sandstone capping. When this has taken place a round hill of Upper Lias shale will have been formed. It is easy, therefore, to see that the hills of Rosedale and Fryup have been formed in a similar fashion. When the Oolite extended across Fryup Gap, it was narrower at this place and broader where the hill is ; the former was eroded away more rapidly, the latter more slowly. And so

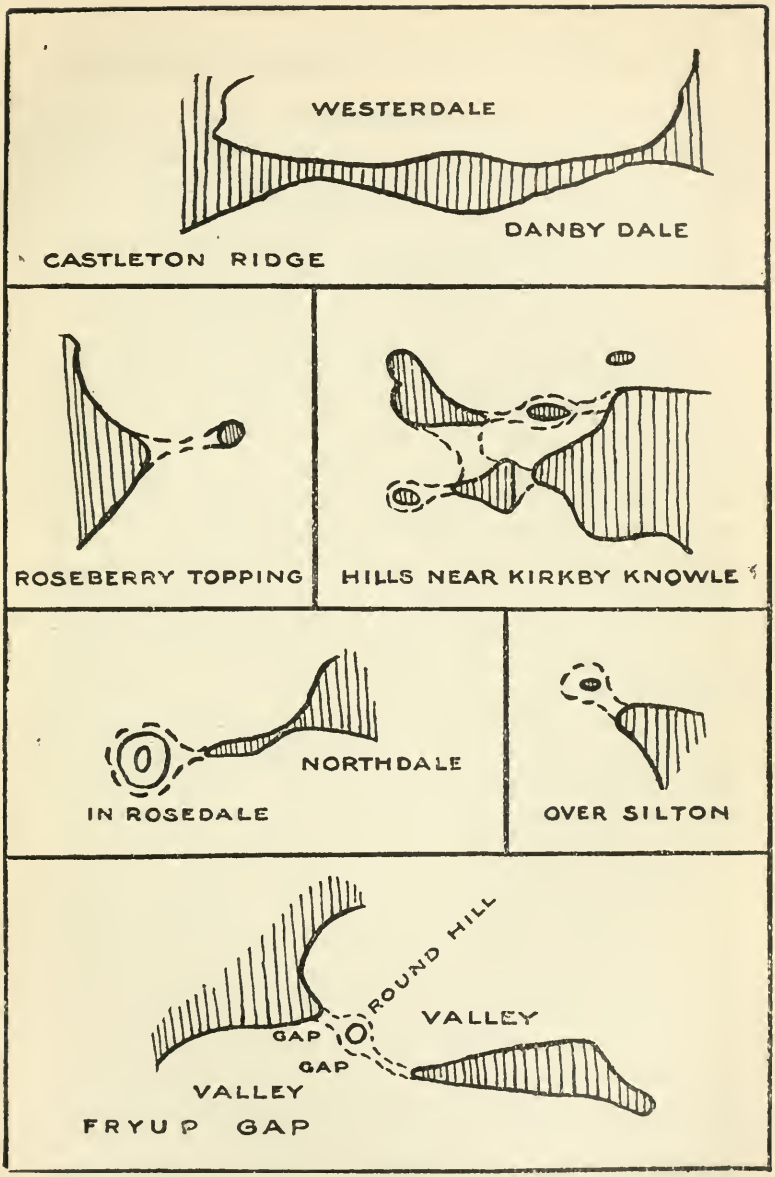


FIG. 56.—DIAGRAM TO ILLUSTRATE THE FORMATION OF OOLITIC AND LIASSIC OUTLIERS.

Shaded parts are Inferior Oolite Sandstone. The unshaded parts are Liassic Shales. The dotted lines represent the former extension of the Inferior Oolite, the narrow necks are worn away, leaving hills capped with sandstone, which, when removed in its turn produces round hills of Lias. The diagram is arranged to show the successive stages of this process.

with the hill in Rosedale, which marks the site of a wider outcrop of Oolite which has long ago been swept away. One part of a moorland ridge may very easily become narrower than another part owing to various causes, principally landslips. Thus, the Castleton Ridge, near St. Helena, is very narrow ; extensive slips, as previously mentioned, have occurred on the Danby Dale side (Fig. 56).

The cutting back of the dales has been an important event in their development, and is well illustrated by the Murk Esk, as pointed out by Mr. Cowper Reed. So far back indeed has this valley receded that its head waters, Eller Beck on the east, and Wheeldale in the west, actually rise south of the anticline. In future ages the heads of the great dales will encroach upon one another, passes from one valley to another will be formed, and ultimately continuous dales from Eskdale to the Vale of Pickering will arise. Important modifications of the drainage will naturally follow and the whole aspect of the high moors will be completely changed.

In the eastern area the dales are small and fall towards the sea. Such are Stainton Dale, Bloody Beck, the River Derwent, the Symes Valley and Troutsdale. This is in accord with the easterly slope of the anticline, but here glacial action has largely obscured the normal courses of the streams.

It will have been perceived that the Ice Age has had little to do with the shaping of the dales, for the simple reason that most of them lie outside the limits of glaciation ; but there is one case worthy of attention in which the Glacial Period may have had some influence. Far away on the wild moors beyond Lilla Cross rises Bloody Beck, which, flowing due eastwards, falls into the rocky ravine of Jugger Howe Dale, a few miles above Harwood Dale Mill (see Fig. 55). Now where the waters of Bloody Beck join those of Jugger Howe Dale some singular features occur. We find that the beck flows over a fine waterfall nearly twenty feet high, through a deep and wooded gorge, whilst parallel to

this gorge, and at a somewhat higher level, runs a dry valley, opening out on the sides of Jugger Howe Dale. In other words, the form of the valley of Bloody Beck at this point may be represented by the letter Y laid horizontally, the lower limb of the fork being the gorge, the upper limb the dry channel. Here are two facts demanding explanation. Why is the outlet bifurcated, and why does the stream flow over a wall of rock ?

It is significant that this happens upon the edge of Jugger Howe Dale—a valley formed during the Ice Age along the ice margin—the line of maximum glaciation being practically represented by its sinuosities. Before the Glacial Period Jugger Howe Dale did not exist ; but the waters of Hellwath Beck in the east and Bloody Beck in the west united not far from where they now join, and travelled down a shallow normal moorland valley to Harwood Dale. Through this valley—that of Lownorth Beck—came the glacier-lake drainage from Robin Hood's Bay and Iburndale, cutting deeply into the moorlands, as well as enlarging and widening the pre-existing dale. Hence after the retreat of the ice, Bloody Beck would flow at a higher level than the floor of Jugger Howe Dale, and would consequently precipitate its waters over the edge of the ravine, forming the waterfall which has cut back some little distance from its original position. Hellwath Beck has two waterfalls in its course for similar reasons.

To account for the origin of the dry gorge is not so easy. It may be due to a lobe of ice which stood on the western side of Jugger Howe Dale and caused the glacial drainage to sweep round it after the manner of an oxbow. That the ice pressed westwards further than the line of the dale may be taken for granted ; for in the Robin Hood's Bay area, several dry valleys parallel to Jugger Howe occur to the west of it, the chief of them being Biller Howe Turf Rigg Slack. If the ice lobe at the exit of Bloody Beck caused the drainage to form an oxbow, on the shrinkage of the ice this oxbow

would be deserted by the glacial waters. The waters of Bloody Beck, however, travelled down the lower segment of the oxbow, leaving the higher and intake segment dry to the present day. It is certainly a rather curious coincidence that an ice lobe should have formed an oxbow exactly at the mouth of the beck; but it may be noted that nearly all waterfalls in North-Eastern Yorkshire can be traced to the effects of the Ice Age in thrusting streams out of their original channels against the rocky sides of the valleys. In this way have been formed the numerous falls in the neighbourhood of Goathland—Thomasin Foss, Nelly Ayre Foss, Walker Mill Foss, etc.

Without entering into further details enough has now been said concerning the origin of the dales. A discussion of all their peculiarities would not only be tedious, but it would be very largely a repetition with varying local details of what has already been stated. We have clearly seen that the dales of the Eastern Moorlands are due to several factors, the chief being the dip of the rocks, which, in most cases, has decided the direction of the streams; the character of the rocks, which has determined the forms of the valleys; and lastly the action of rivers, springs, snow, frost and rain, which have led to their excavation. Hence there has indirectly resulted the peculiar distribution of the moors on the Bajocian strata, showing once again how dependent the plant life of a district is upon its geological history.

On calm days when geological processes are reduced to a minimum it is extremely difficult to realise that the dales are the result of erosion. Since calm days outnumber stormy ones when denudation reaches a maximum, we begin faintly to understand the length of time required for the excavation of a dale. The sense of their antiquity is still further emphasised by our looking at deposits of the Ice Age that may exist in them, deposits still retaining their almost original forms, though left there thousands of years ago by the ancient ice.

CHAPTER XIII

THE CLEVELAND AND HAMBLETON HILLS.

THE northern boundary of the moors coincides in the main with the great Jurassic escarpment of the Cleveland Hills. Rising abruptly from the plain, this picturesque range of uplands has a more imposing aspect than any other escarpment or range of hills in North-Eastern Yorkshire. Viewed from the high moors behind Robin Hood's Bay, the Tabular range looms boldly forward on the southern horizon ; as seen from the head of Scugdale, the outliers of Easterside and Hawnby Hill are most impressive ; but no part of the Tabular escarpment can compare in ruggedness, boldness and elevation with the Cleveland Hills from Roseberry Topping to Scarth Nick. As contemplated from the Vale of Stokesley, they cannot but charm and impress us with their ever-varying aspects. When the atmosphere is heavily charged with moisture they are sapphire blue, deepening in intensity when rain clouds roll their black masses along the flat summits. Under these conditions only a grand succession of bold curves outlined against a gloomy sky can be discerned. Each great land-form—the cone of Roseberry Topping, the flat-topped Hasty Bank, the sugar-loafed shape of Cold Moor, the hog-backed sweep of Cranimoor (Cringle Moor)—looms up yet larger as day wanes and dark shadows fall athwart its crags and slopes. In clear sunny weather, especially after a period of drought, the hills provide us with other aspects. Every detail then becomes visible, so that even at a distance of several miles every wood, crag, grassy bank and scar stands out with remarkable distinctness, though apparently much reduced in size. Sometimes

the setting summer sun flushes their summit crags with rosy light and we behold the portals of an enchanted land.

Speaking generally, the moorland parts of the Cleveland Hills run from the neighbourhood of Ingleby Arnecliffe due eastwards to that great recess, Greenhow Botton. They then trend north, *via* Battersby Crags and Easby Moor, to Roseberry Topping, where they once more turn east along the south side of the Guisborough valley. The chief and undoubtedly the most impressive part of the Jurassic escarpment lies between Greenhow Botton and Swainby, where the range is cut up into a succession of hills separated by deep cols or passes. The easternmost of these hills is the long flat-topped Hasty Bank, a curved mass of rocks reaching a height of 1300 feet at Raven Scar. Its singularly narrow grassy summit rarely exceeds three hundred yards in width, and in some places is only one hundred yards or even less across. On the east it is divided from the elevated tracts of moorland round Botton Head by a narrow pass—Hagg's Gate—whilst a similar but wider col separates it on the west from Cold Moor. These cols correspond to the two head branches of the great Bilsdale valley. Viewed from Ingleby Moor, Hasty Bank has a hog-backed outline quite different from its tabular appearance as seen from the north.

At Hasty Bank there is evidence as to the way in which the hills are degraded by the weather. The eastern extremity has been the scene of many landslips, the last of which left a huge scar of bare rock on the hill side. Great screes of shale and sandstone fallen from the cliffs obscure all the strata below the top of the Alum Shale, and at the foot of the talus heaps immense blocks of sandstone make a scene of wild confusion and rocky desolation. A large landslip took place here many years ago. It probably originated in a joint parallel to the face of the cliffs becoming wider by the action of frost and rain, whilst at the same time the water percolating through the porous sandstone

was thrown up by the impervious shales beneath. In this way the face of the cliff becomes insecure, and sooner or later slips down the slopes with a tremendous crash.

At the western end of Hasty Bank occurs that familiar group of boulders, the Wainstones, consisting of pillars or columns of sandstone more or less isolated from one another, together with a fantastic jumble of rocks of all shapes and sizes. Derived from the Bajocian sandstone of the hill summit, the Wainstones exhibit the influence of the weather upon this kind of rock. Vertical lines of joint or " backs " have been widened without the masses slipping away from the face of the cliff, and as these masses have been attacked on all sides by the weather, they have slowly been sculptured into picturesque pillars or monoliths. Varying degrees of hardness in the successive layers of sandstone have produced unequal erosion along lines of bedding—the softer layers being worn away more rapidly than the harder—so that we sometimes come across masses of rock supported by a comparatively slender pedestal.

Still proceeding westwards we reach the interesting outlier of Cold Moor, likewise 1300 feet high. From the plain this hill appears quite conical, though in reality we are looking at a section of a roughly oval piece of moorland, two miles in length from north to south, and often nearly a mile wide. Cold Moor divides the heads of Bilsdale and Raisdale, and nothing can be more impressive than its long sweeping slope rising from the south to the very edge of the escarpment.

Beyond Cold Moor comes the col at Donna Cross which is succeeded by the hog-backed outline of Cringle or Cranimoor. Cranimoor is a magnificent land-form, triangular in shape, completely isolated, and attains an altitude of 1400 feet. It is perhaps the finest hill in the whole escarpment.

A long flat col, Green Bank, marking the head of Raisdale, separates Cranimoor from the steep slopes of Carlton Bank,

where the escarpment begins to trend south-west to Live Moor above Whorlton. The altitude here falls considerably, being only 1025 feet, a fact of some significance in the history of the hills. West of Live Moor the deep Scugdale valley opens on to the Cleveland plain from the east-south-east; its western side being breached by the fine gap of Scarth Nick leading down to Osmotherley.

That deep embayment at their western extremity, Greenhow Botton, around which the moors attain their greatest elevation of nearly 1500 feet, is perhaps the most remarkable feature of the hills. The Botton lies almost a mile to the south of the line of the main range of uplands, and has remarkably steep and precipitous sides on the south. These sides are wild and rugged in the extreme, and are gashed with numerous water-courses. Of these courses, Blue Bell Trough is the largest, and forms an almost precipitous cleft or narrow ravine on the slopes below Urra Moor. Practically streamless in summer, Blue Bell Trough in winter, when snows lie deep on the northern face of the hills, becomes a roaring torrent, turgid with debris.

At Rudd Scar, above the Rosedale incline railway, the massive character of the sandstone is well-shown. High cliffs, down whose face streams trickle, with huge screes of fallen blocks at their base, form a wild and rugged scene. Here denudation slowly wears back the face of the cliff. In wintry weather, water percolating through cracks in the stone becomes frozen, and forces the rock apart. Combined with the erosive power of running water, this process loosens blocks of sandstone along lines of joint and bedding, until they are rendered so insecure that they fall away and crash on to the slopes below. Along the sides of the Botton, huge blocks of sandstone lie scattered down to the floor of the valley, showing how effective is this method of erosion.

Slips of stone and soil frequently happen owing to the action of small springs. The slopes or screes of fallen

material are in their turn attacked by the weather, but through the formation of soil may become grassed over before being removed.

Of the strata composing the hills little need be said. The lower slopes are formed of the Lias, and the summits of the Estuarine sandstones of the Inferior Oolite. In almost every instance the nature of the slope has been determined by the nature of the rocks. The Sandy Series of the Middle Lias being much harder than the shales above and below, occurs as a prominent scarp near the foot of the hills, forming in some localities spurs running out into the lowlands, as at Lazenby and Yearby Banks near Eston ; Bousdale Hill, a long ridge near Pinchingthorpe ; and the steep scarp above the river Leven at Easby Wood. On the slopes of the hill on which stands Captain Cook's monument, the outcrop of the Sandy Series is deeply grooved by channels caused by running water.

The Ironstone Beds form a lesser scarp above the one which has just been described. Harder than the shales above but softer than the sandstones below, it occupies an intermediate position in the slope of erosion and can be well seen on Roseberry Topping. The soft upper Liassic shales have, as a rule, a gentle non-prominent slope, whilst above them rise the craggy cliffs of sandstone. These general features are often altered by slips, as at the western end of Hasty Bank, and on the great precipitous scars of the Middle Lias below the pass of Green Bank. Much, too, of what has been here said concerning the form of the dale sides is applicable to the slopes of the hills, the rocks being identical in both.

The details of the slope of erosion become very well-marked in snowy weather, when the Cleveland Hills appear truly grand, standing out like miniature Alps against the clear blue of the sky. Since the snow lies unevenly on them, every crag and scarp may be seen with great distinctness, the sandstone cliffs and other precipitous places showing black, whilst the slopes beneath are dazzling white.

The origin of the escarpments of the Vale of Stokesley appears to be associated with special phases in the developmental history of the River Tees and River Leven. For if the river system at this end of the Jurassic tableland had operated in the same way as that of the dales, it is difficult to understand why all the Oolites and most of the Lias have been swept off the plain. Unless the moorland strata never existed here (an improbable hypothesis), we can only account for their absence by erosion, more rapid and more powerful than that which has been at work elsewhere in the district.

That the Cleveland escarpments once extended further northwards cannot be questioned; a conclusion borne out by the fact that in the Eston Hills we find the same succession of strata as in the hills above Stokesley. How much further north still the Eston escarpment extended cannot be ascertained; but probably at the time of the Miocene uplift the vales of Guisbrough and Stokesley were overlain by all the higher beds of the Lias and Oolites, and a continuous line of hills ranged along the southern or even the northern banks of the Tees. According to Mr. Cowper Reed, at that epoch the River Leven had originated and drained westwards into the Tees, the influence of which river with its greater volume of water, and consequently greater erosive power, led to a more active denudation of the Jurassic rocks along their north-western outcrop. Hence it has been partly responsible for the more rapid recession of the escarpments overlooking the low grounds of Cleveland.

A fact not to be left out of consideration in this connection is the rough parallelism shown by the course of the Tees and the line of the Cleveland Hills. From Barnard Castle to Darlington the Tees flows eastwards, and at Dinsdale trends north-east, thus approximately following the general run of the Jurassic escarpment. As Mr. Reed has shown, the Tees-Leven-Esk once probably formed a continuous river. The waters of this river, however, were diverted and turned

north-east, the lower part of its course became the Esk, whilst the Leven arose as a tributary flowing westwards in the old valley of the Tees-Leven-Esk. Kildale Gap is thus accounted for, and it must be obvious that this activity of river erosion plus the ever present atmospheric erosion, led to the more active denudation of the north-western area of Cleveland.

Flowing into the Leven are two tributaries—Ingleby Beck rising in Botton Head, and Swainby Beck rising in Scugdale. Ingleby Beck flows north-west from the watershed, and arose after the Miocene uplift, the dip of the rocks determining its direction as with the other dale-streams. Probably it flowed down a dale, the western wall of which has long ago been swept away. The eastern wall, however, remains, and this is the westward facing slope of the Botton, the head of which still retains all the features characteristic of that of a dale.

The origin of Scugdale is not so clear, and in many respects it is one of the most interesting of all the dales. For one thing, it is very deep with bold slopes and sides; and it breaks through the Jurassic escarpment in a direction contrary to the dip of the beds which is eastwards, whereas the dale points a little north of west. Moreover, it is a much-faulted valley, more so than any other in the district. One of the faults runs along the length of the dale on the northern side, having a downthrow on the north of quite 100 feet, whilst crossing the dale from south to north is another fault which extends as far as the eastern side of the Whorlton outlier. If we follow the line of old shale heaps left by the jet workers on the southern slopes of the valley, we notice that they dip east-south-east from Scarth Nick to Harfa Bank, beyond which we find that they have an opposite dip, viz.: west-north-west; the change of dip being probably due to the north and south fault referred to, and here extending into the southern side of the dale. It is suggestive that there should be this westerly dip coinciding

with the course of the valley, but that this has initiated its direction does not seem likely when we remember that this dip is suddenly changed into an opposite one. Messrs. Tate and Blake thought that Scugdale belonged to the southern set of dales in contradistinction to Greenhow Botton which belonged to the northern set; but this must be an error on their part, since Scugdale obviously is the last remnant of a large dale which may, in former ages and far beyond the present outcrop of the Oolites, have trended northwards in the same way as Danby Dale, etc.* The same authors also hint that this peculiar valley may have arisen along the line of the east and west fault, and this is not unlikely. Again, the dale may be due to the cutting back of some tributary of the Tees rising on the slopes of the hills when their escarpment extended further north, and being an active and powerful little river, its head waters might have worked headwards through the escarpment faster than this receded.

By the co-operation then of all these factors the great north and west escarpments of Cleveland were produced. The recession of the main range of hills, however, caused the upper reaches of the great Bilsdale valley to be beheaded. That is to say, the cols of the escarpment at Hagg's Gate, Garfit, Donna Cross and Green Bank, correspond to the slopes and floors of the branches of Bilsdale. Formerly extending further north, these valleys have had their upper parts swept away by erosion, resulting in that picturesque succession of hill and hollow so characteristic of the great Jurassic escarpment. All the stages in this method of beheading valleys can be seen along the whole range of the hills. Above Guisbrough the two heads of Sleddale are being gradually decapitated. One head—at High Cliff Gate—presents but a slight depression in the outline of the escarpment; the second head has been cut away to a much greater

* "Yorkshire Lias," p. 195.

extent, probably because it extended further to the north. Consequently there is a much deeper and broader col on the edge of the escarpment at Cod Hill. We have only to imagine High Cliff Gate being eroded much further back to see that the bold crag of High Cliff itself would become an outlier or hill like Cold Moor or Cranimoor.

Roseberry Topping is due to the same erosive agents. Between Easby Moor and the Topping is a small embayment caused by small streams flowing from the escarpment. On the Newton side of the hill a deep broad col separates the outlier from Newton Moor. This col is partly due to the recession of the northern escarpment beheading one of the valleys of the streams just mentioned. In glacial times some overflow of water must have taken place through this col, and this would still further deepen it. Viewed from the north or south Roseberry Topping presents a very characteristic form. Its eastern slope is decidedly convex, whereas the western slope is somewhat concave, showing that this latter has suffered most from the weather, rain and atmospheric erosion, these agents being decidedly stronger from the west and south-west than from any other point of the compass. The hill, too, is clearly reminiscent of the time when the Round Hills of Fryup and Rosedale were capped with Oolite. When the Oolitic cap has been worn from the summit, Roseberry Topping will then form a round hill of Lias (Fig. 56).

Mention must be made of the singular outlier of Whorl Hill between Swainby and Faceby, a small mass of Upper Lias and Oolite that has been let down between two faults which bound its east and west sides. These have undoubtedly led to its preservation, but it is not at all clear as to how the gap between the hill and Whorlton Moor has been carved out.

During the Glacial Period the Cleveland Hills presented an impassable barrier to the ice sheets. Sweeping from the north, the glaciers impinged directly on their face, but were

unable to surmount them. Observe here the subtle interworkings of causation. Causes which we have just dealt with produced the bold escarpments of Cleveland; these escarpments in their turn caused the ice sheets of a later age to be hindered in their almost resistless advance. If the escarpments had been lower so that the ice overflowed them there would have been little or no driftless area with an Arctic fauna and flora, and much less moorland, for in that case the drift deposits would have considerably modified the original moorland soils.

Little change was wrought on the hills during the Ice Age. Here and there the drainage of the slopes was obstructed, and flowed into the ice-free country beyond. In this way arose that great notch in the escarpment at Gribdale Gate, between Great Ayton Moor and Easby Moor, whilst the obstructed drainage of Scugdale gave rise to two lake overflows, Holy Well Gill and Scarth Nick. The former occurs on the moors on the western side of the valley at a height of 1000 feet, the highest overflow in North-Eastern Yorkshire. A retreat of the ice opened a lower channel and the great pass of Scarth Nick was excavated. Visible for long distances, Scarth Nick is one of the most imposing evidences of Professor Kendall's theory in North Cleveland.*

When the ice margin stood at the foot of the hills, a type of dry valley was formed characterised by large mounds of drift on the iceward side and the steep slopes of the hills on the other, the obstructed drainage flowing between them. Such channels may be seen at Pinchingthorpe, Great Ayton, Ingleby and Whorlton.†

At Ingleby Arncliffe the Cleveland Hills trend southwards as far as Osmotherley; beyond which village to Coxwold the escarpment is known as the Hambletons, a range that differs considerably from the one we have been studying, and to which we must next devote a little attention.

* Kendall, op. cit.

† Elgee, "Glaciation of North Cleveland," Proceedings of the Yorks. Geol. Soc., 1908.

The Cleveland and Hambleton Hills

The Hambletons, as we have frequently stated, form the western boundary of the moors, and are due to the excavation of the great vale of York. How much further to the west they once extended we cannot say with any certainty, but the gradual recession of the escarpment has led to some very remarkable features, owing chiefly to the circumstance that the whole of the Jurassic system of rocks, from the base of the Lias to the top of the Coralline Oolite, constitutes the slopes and cliffs of this noble range.

Since no valleys have been beheaded by the recession of this escarpment we do not find that succession of hill and hollow so characteristic of that of Cleveland. On the contrary, the tabular summits sweep in an unbroken line from Black Hambleton to Roulston Scar, with great cliffs of Calcareous Grit and Kellaways Rock that have been caused by immense landslips, as at Kepwick, near Boltby, at Whitestone Cliff and elsewhere. At the latter place, the sinking of the hinder part of the slipped mass, more readily than the front which forms a great ledge or undercliff, has produced a hollow, now filled with water and the site of the picturesque Lake Gormire.* Similar and smaller slips often have pools in the sunken part, as may be seen in our photograph of the Cotton Grass in Fig. 19, where the water has collected in the hollow of an undercliff due to landslips.

Below the cliffs of the Middle Oolites comes the outcrop of the harder Bajocian rocks, which, since they have been trenched by numerous small valleys, occur sometimes as spurs, and sometimes as singular detached outliers. Below the Inferior Oolite is the slope of the Upper and Middle Lias, and in fact we may compare the Hambletons to the Cleveland Hills with the Tabular Range placed on top of them! The Hambletons, however, do not attain the altitude of the Cleveland Hills, owing to the southerly dip of the strata and their diminished thickness, especially in the case of the Lias and the Inferior Oolite.

* Fox-Strangways, op. cit.

Moorlands of North-Eastern Yorkshire

We have in Chapter X. referred to the heather-clad spurs of Inferior Oolite which run out into the plain at the foot of the Hambletons. These are due to the erosive action of streams rising in the escarpment and to the excessive hardness of the rocks, and are especially noticeable at Osmotherley, Over Silton, Cowesby and Kirby Knowle. Some masses have become separated from the main outcrop and form remarkable outliers, such as Woolmoor south of Cowesby, Mount St. John and four smaller outliers near Kirby Knowle, (Fig. 56) and the great mound of Hood Hill in front of Roulston Scar. Nor must we omit to mention the long narrow hill of Borrowby to the east of Northallerton.

These hills are particularly interesting, for they have become detached from the escarpment by different methods. A glance at the geological map shows that Woolmoor and Hood Hill are separated from the escarpment by dry valleys which have every appearance of being lake-overflows. Though the glaciation of the Hambletons has not yet been investigated in the light of Professor Kendall's researches, there can be no doubt that the obstructed drainage of the slopes formed lakes which drained away southwards. The valleys between the outliers and the escarpment do not appear to have been formed by the wearing back of either side of the spurs to which the hills must have once belonged, but north of both is a recess in which the water of the slopes could have accumulated against the ice margin in the Vale of York. The probability is that these lakes drained southwards across the spurs in question, cutting deep valleys and leaving the ends of the spurs as conspicuous hills.

The outliers of Inferior Oolite between Kirby Knowle and Feliskirk seem to have been produced by the wearing away of narrow necks of the same rocks, in the manner of the Round Hills in Fryup and Rosedale. It is very obvious that by the time the sandstone capping is worn off, small Liassic hills will be formed such as may be seen at the end of the spur at Over Silton (Fig. 56).

Photo by] FIG. 57.—FREEBOROUGH HILL FROM THE NORTH. *[Frank Elgee.*

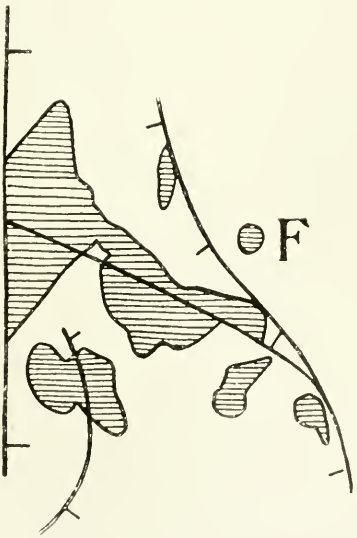


FIG. 58.—GEOLOGICAL STRUCTURE OF FREEBOROUGH HILL (F) AND VICINITY.

(The shaded parts represent the Kellaways Rock; the unshaded the Upper Estuarine Series. The black lines are faults, with short lines on the downthrow side).

The Cleveland and Hambleton Hills

Before finally leaving the geological history of the moors we must consider the origin of one of the most interesting hills in the whole district, Freeborough Hill near Moorsholm, which affords a beautiful illustration of the principles involved in the formation of moorland land-forms (Fig. 57). Long rendered a landmark of note by its singular conical shape and isolation, this conspicuous hill stands in the south-western angle of the North Cleveland watershed, and reaches an elevation of 800 feet above the sea, and about 150 feet above the surrounding plain or Freeborough Skirt, as it is called. And yet, notwithstanding this inconsiderable altitude it can be seen for miles around ; from Danby Beacon, from the heights of Huntcliff and Boulby, from the hills above Boosbeck, and from many other points of view it is visible, rising like a large tumulus from the level of the adjacent moors. Indeed, at one time, Freeborough Hill was actually regarded as an ancient grave mound, as testified by the old lines :—

"Freeborough's huge mount, immortal Arthur's tomb!"

Geologically, as we have formerly stated, the hill is an outlier of the Kellaways Rock lying in the synclinal trough north of the Esk. By due recognition of the geological structure of the ground, and with the aid of the various erosive processes, it is quite possible to trace not only the manner in which Freeborough Hill was formed, but also to understand why similar hills do not exist in greater numbers.

The geological structure of the neighbourhood can be seen on the annexed sketch map (Fig. 58). Speaking of the faults in this locality Mr. Barrow says :—

"Close to the south-west corner of the main mass of the Kellaways Rock is a small detached portion of the same bed, evidently bounded on the east side by a fault. This continues for some distance to the north-west, and must, near Freeborough Hill, have a considerable throw, in fact,

as much as the height of Freeborough, if not more. The Kellaways Rock on Moorsholm Moor dips sharply north, and would, but for the break in the beds, pass completely under this hill. As this rock actually caps the hill it is easy to see roughly the amount of the dislocation."*

Now it is to be observed that the hill stands on land between the head waters of Kilton Beck, Haredale on the west and Haw Rigg Beck on the east. As both streams flow over the faults, they have evidently cut down across them from higher strata which have long since been removed, and which would thus appear to have either been unfaulted, or if with faults these made no show at the surface. To the operation of these streams plus atmospheric and spring erosion (which latter would be active here owing to the impervious Cornbrash shales throwing up water that had traversed the pervious Kellaways Rock), is therefore due the wearing back of Freeborough on the east, north and west.

On the south the fault appears to have been the main factor in the separation of the outlier from Moorsholm Rigg. For with the removal of the superincumbent strata, this break would always be a line of weakness along which weathering and spring erosion would work. This erosion and the fault would tend to form a scarp or cliff running across the Rigg, with a base consisting of the soft Upper Estuarine and Cornbrash Shales. In time this scarp would gradually recede to where Freeborough now stands, and form the south side of the hill. If it be objected that the fault would hardly show as a scarp, the reply is that another fault in the Kellaways Rock actually shows such a feature. This occurs just west of Moorsholm Rigg, and crosses the Guisbrough high road, where Low Brown Hill and Brown Hill mark distinctly the position and amount of the dislocation, and the different levels of the base of the Kellaways Rock.†

* "Survey Memoir," pp. 77-8.
† Barrow, op. cit.

We now have a block of rock attacked on all sides by denudation ; two stream slopes on the east and west, the weather and springs on the line of fault, and to the north the natural escarpment of the Kellaways Rock weathered backwards. Assailed on every side, the outlier, in the course of ages, was gradually reduced to its present dimensions and completely detached from the surrounding uplands. The formation of the hill had already been achieved before the Glacial Period, but a further cause must then have operated to deepen the depression between the hill and the Rigg. Professor Kendall has shown how the ice-sheets swept into this corner of Cleveland, and impounded the waters of Lockwood Beck and Haredale, causing them to flow along its edge. In this way two curious dry valleys on the slopes of Moorsholm Rigg, Hole Skew and Spring Head Hole, were excavated. After these were rendered functionless by a recession of the ice, the still obstructed drainage must have flowed along Freeborough Skirt, eastwards or westwards as the case may have been. Hence a further lowering of the flat between the hill and the Rigg.

Freeborough was probably completely covered by glaciers, and though no drift is found on the summit, yet this is singularly rounded and is in marked contrast to those of Blakey and Roseberry Toppings which stood above the ice sheets.

This geological history of Freeborough Hill receives verification when compared with that of other moorland outliers. That of Eston is the most remarkable and worthy of some attention, since not only does it confirm the origin of Freeborough Hill, but it also enables us to understand the patch of moorland existing there, the most northerly moor in the area under consideraton. The rocks composing the Eston Hills include those strata lying between the Lower Lias and the Moor Grit. The Fossiliferous Grit of the Grey Limestone Series occurs on the outlier towards the western end where it forms a conspicuous scarp at its

outcrop. The northern face of the Eston Hills appears to have arisen from the erosion of the rocks backwards from some more northerly outcrop, forming part of the right bank of the Tees. To the south the hills are separated from the main escarpment by the wide Guisbrough Valley, the origin of which is by no means apparent, and which presents several peculiar features. Between Pinchingthorpe Station and Scugdale Farm in the valley is a low watershed to the east of which all the streams fall into Skelton Beck. These streams have their source in small valleys in the southern escarpment above Hutton Lowcross, and their present trend shows that in pre-glacial times their drainage also travelled in that direction. West of the watershed there is no definite stream, but only artificial channels made to drain the low-lying grounds.

To the action of these streams must be ascribed in part the origin of the Guisbrough Valley, but a further cause must have co-operated to render it wider than it otherwise would have been. For the Eston Outlier is faulted along its southern side, the amount of the downthrow varying from 300 to 400 feet, and bringing the Oolite against the base of the Lias. There can be little doubt that this would constitute a line of weakness, owing to the fact that the softer rocks of the Upper Lias would be much exposed on the south and thus be worn back rapidly on that side. West of the before-mentioned watershed this fault would also operate, and, with the recession of the escarpment on the west, the streams flowing into Skelton Beck would be beheaded. That the fault has had influence in making the Guisbrough Valley as wide as it is at present is confirmed by the sudden narrowing of the valley of Skelton Beck between Upleatham and Airy Hills. The south end of the former hill is intersected by a continuation of the fault here possessing a downthrow of twelve feet only, which would have little influence in the formation of the valley of Skelton Beck.

Thus it is probable that the Eston Hills owe their preservation to this great fault, but the conditions are the opposite to what they are at Freeborough. In other words, the Eston Outlier and Moorsholm Rigg correspond, both being the downthrow side of the fault ; whilst the Guisbrough escarpment and Freebrough Hill correspond, both being the upthrow side of the fault.

We have now concluded our account of the origin of the Cleveland and Hambleton Hills, and indirectly the northern and western boundaries of the moors which follow more or less closely the summits and slopes of this range of uplands. Although at first sight resembling sea-cliffs, we have seen that they can be accounted for by subaerial denudation acting throughout immense periods of time. It is not, however, impossible that the sea may have had something to do with their shaping, but all records of this incursion of " ocean's wide domain " appear to have utterly vanished.

CHAPTER XIV

ANIMAL LIFE ON THE MOORS.

ASSOCIATED with the moorland vegetation is a characteristic suite of animals adapted not only to the general conditions of life on the uplands, but also to the plants, to which they are largely indebted for sustenance and shelter. Apart from their own intrinsic interest these animals cannot be disregarded even in a botanical account of the moors, for whatever has been the history of the plants must have vitally affected and largely determined the status of the ericetal fauna. If the evolution of the fauna proceeded *pari passu* with that of the flora, both animals and plants should possess features in common owing to parallelism of development. Hence, before we can consider the moor problem as completely investigated, we must examine the fauna to ascertain what data it will reveal concerning the origin of the moors.

As in the case of the flora so with the fauna ; it may be considered from two points of view. The first treats of the fauna as it is at present, its species and their distribution, its division into natural groups or associations, the habits and adaptations of its diverse components to their conditions of life, and above all furnishes data whereby its origin can be elucidated. The other treats of the origin and history of the animals which live upon the moors, their lines of past migration and distribution, and the changes which the fauna has undergone in relation to former climates and former geographical conditions ; more especially it considers the evolution of the fauna and the causes which have contributed to that evolution. In dealing

with this complex problem we find that our enquiries, as in the case of the plants, are rendered difficult by the lack of palæontological evidence. Seeing that the typical ericetal animals are chiefly insects which leave few fossilised remains, palæontology necessarily furnishes no direct clue to their past history. Hence an interpretation of the moorland fauna must be largely speculative.

The chief data to be employed in investigating the problem are :—the consideration of the geographical distribution of the ericetal animals and their near allies, together with the nature of the climates to which they are adapted ; and the combination of these facts with the history of the moorland plants, and the changes of climate which have occurred within recent geological times. Uniting the two sets of data we shall find that, by this means, a tolerably clear idea can be obtained of the history of the fauna of the moors.

Although there is no direct evidence as to the character of the pre-glacial fauna of the Eastern Moorlands, nevertheless the mammalian remains discovered in the famous Kirkdale Cave near Kirby Moorside throw an indirect light upon the matter. As is well-known, this cave was formerly a hyæna den, into which these animals carried the bones of the reindeer, Irish elk, bison, cave bear, lion, hippopotamus, rhinoceros and horse. It seems probable that the occupants of the cave flourished in pre-glacial times, for the mammalian remains found in the post-glacial peat bogs only comprise, at any rate in Cleveland, those of the red deer, reindeer, wild boar, and wild ox, but not such animals as the hyæna, mammoth, rhinoceros or hippopotamus.

From fossil remains it cannot be proved that all the moorland birds and insects existed in pre-glacial times, though it is extremely probable that they flourished in the late Pliocene or even earlier. The identity of numerous later Tertiary mollusca, plants and mammals with those of to-day, points to this conclusion ; but on the whole, the pre-glacial fauna of the district, as the remains from

Kirkdale show, must have been richer in species. Arguing from these remains, it seems reasonable to infer that the insects of the pre-glacial age, or Pliocene, must have presented similar features to the mammalia ; that is, an intermingling of African, northern, and temperate species, although of this we have no palæontological evidence. Nor does there appear to be any trace left in the present insect fauna of the extreme southern species of pre-glacial times. In this respect they agree with the post-glacial mammals, and it has therefore been concluded that the Ice Age must have been the chief factor in exterminating the southern forms. So far as we can tell the origin of our familiar moorland birds and insects goes back to a time anterior to the Ice Age, though, as I hope hereafter to show, some species may have been evolved since the close of that period.

As stated in Chapter VIII. all the species of a genus have descended from some proximate or remoter ancestor, and it has been argued that wherever we find them most numerous, such a locality must be regarded as a centre of origin or distribution, from which the various forms have radiated to the furthest limits of the range of the genus. In many instances, however, a genus appears to have no definite centre of distribution ; its species are spread over wide areas without any marked concentration in any one region. Again, where the species of a genus are most numerous at present, palæontology proves that this was not formerly the case. Particularly clear is this qualification in a group of marine bivalve mollusca, *Astarte*, found on the Yorkshire coast, which now attains its maximum development in cold northern seas, whereas in Jurassic times—the Corallian stage —the same group was most strongly represented in mid-European, semi-tropical and corallian seas. Similar instances occur amongst other genera of both land and marine animals. In the case of insects, therefore, where fossil evidence is very deficient or altogether fails, speculations as to their centres of origin must be hazardous. A further

Fig. 59.—Head of Moor Sheep.

qualification is necessary if the present distribution is such as to show that the species cannot have originated in an area where there is a decided multiplication of forms. A common British beetle (*Creophilus maxillosus*) well illustrates this point. The genus contains half-a-dozen species in New Zealand, one in South America, and the British form. But we can hardly say that New Zealand is to be regarded as the place of origin of *Creophilus*, for the distribution of the species evidently took place when the configuration of land and water was quite different, and the actual centre of origin may have been in lands now beneath the sea.

Despite these qualifications, however, we may accept the theory of centres of distribution on the ground that wherever species are numerous in any given area, they must have become adapted to the life conditions in that area, especially if these conditions are of a strongly marked kind, as for example in the Grouse genus. When the distribution of a group of species belonging to different genera of insects and the *plants on which they feed* points to some fairly distinct geographical region, we may conclude with some confidence that they have both arisen in that area ; and here we perceive wherein lies the great advantage of comparing the elements of a faunal association, if we may so term those distinct assemblages of animals which live on moors, coast sand-dunes, coast cliffs, and in salt marshes, fields, woods or swamps. If we tried to ascertain the special history of each species we should assuredly fail in many instances ; whereas by endeavouring to ascertain the history of a faunal group by observing what is common in the distribution of its diverse components, we obtain a more or less definite insight into the history of each species of the association. A concrete illustration of these indispensable preliminary remarks we shall find in the origin and evolution of the fauna of the moors, the members of which we may proceed to discuss in more detail, beginning with the highest forms and working down to the lowest.

The moors possess no endemic mammalia, those species which occur being stragglers from the woods and cultivated areas. Rabbits are not unusual on heathy pastures, such as Dalby Warren near Pickering. Hares may frequently be found on the lower moors bordering the valleys, and I have seen numbers of them in the vicinity of the Falcon Inn.

The moorland foxes are celebrated, and differ a good deal in colour from lowland Reynards, being of a markedly grey or even silvery hue. I am indebted to Mr. J. Fairfax Blakeborough, the well-known sporting journalist, for the following interesting note concerning them :—

" There can be little doubt that the *true* hill-fox is quite different from the low country fox ; though this has been less apparent in later years when to re-stock the countries where mange has played such havoc, litters have been brought from the hills and fastened down in low country coverts ; whilst for some years there has been a continuous trade between England and Scotland in foxes, no hunting taking place in the Highlands. The hill *dog* foxes do visit the low country in the breeding season ; of that there is no doubt, as we occasionally find them with hounds, and have wonderful runs to some earth on the moors, of which no low country fox could know. It is an interesting fact, however, that when the Hurworth and Cleveland foxes were dying on all sides with mange in the low country, in the Bilsdale and Farndale countries (the hills and moors immediately above) the foxes were quite clean, which would show the hill foxes do not use low country earths or associate with low country foxes except when breeding. The hill foxes have their earths on the moors, whilst they use old jet workings very frequently. I should say the big *moorland* fox is now very scarce, though crosses are frequently met with. You will very rarely find a lowland fox take to the moors but once a moorland (hill) fox always a hill fox."

Sir Alfred Pease states that the fox hounds of the Cleveland district are lighter in colour than other packs in order

that they may be more easily seen against the dark heath vegetation.*

Passing over the mole, whose general absence from the moors has already been commented upon (Chapter II.), and merely noting that occasionally mice and voles occur, whose distribution over the moorlands has yet to be worked out, we must pay some attention to an animal which, though domesticated, is nevertheless an essential element in the fauna, the black-faced moorland sheep (Fig. 59). Belonging to the most vigorous and most courageous race of their kind in Britain, and characterised by their black and white faces and limbs, and their coarse and shaggy wool, these animals are a harmonious and familiar feature of the animal life. More or less present everywhere, they exercise no little influence upon the vegetation. Swards of grass are nibbled down to a smooth turf; Furze bushes are also eaten when the young and spineless shoots begin to sprout, and in this way arise the singular irregular shapes of these shrubs; young shoots of Heather and seedling trees are also subject to their depredations. But the most important change effected by these ruminants is in manuring the soil with their droppings. Everyone will have noticed how walks frequented by sheep become grassy, and such walks often run for miles through the Heather. Their dung improves the peaty soil, and enables a better class of plants, from the agricultural point of view, to grow; whilst, if the animals are kept in large enclosures, grass has a tendency to prevail within the enclosed area, and by this means poor heathy land can be greatly improved, so that there is much truth in the Spanish saying, "the golden foot of the sheep." What we here observe to be a cause under domestication may well have acted as a cause in Nature. Where wild sheep are abundant their presence must exert a considerable influence upon the plant life; and if they

* "Cleveland Hounds as a Trencher-fed Pack," Sir Alfred Pease, Bart.

frequently change their haunts, or if in former ages they were compelled to move from one country to another, similar influences must have operated more powerfully.

The moor sheep closely resemble in colour the numerous boulders of grey grit so characteristic of the uplands. This resemblance is noticeable even in daylight; but in the evening, when dark shadows fall across the moors, it is quite impossible at a little distance to discriminate between a scattering of grey gritstones and a flock of sheep at rest upon a slope. Undoubtedly the resemblance is accidental so far as this district is concerned, but it supplies reason for the harmony existing between the "black faces" and their environment. I suspect, however, that this harmony is of remoter origin, for where do we find sheep most numerous in the wild state? On mountains and mountain slopes, to which habitats they have become adapted, and to the boulders and crags of which their colours doubtless assimilate as a protection against the raids of carnivora; so that on our moors the sheep are kept under conditions approaching those of their ancestors in the mountains of Europe and Asia. The resemblance may even be more adaptive than we suppose, though it ceased to be of utility to the animal after the disappearance of all wolves, bears and other carnivora from Britain. Whether wild sheep ever flourished in North-Eastern Yorkshire we cannot definitely say, but in the pre-glacial Forest Bed of Norfolk the remains of a species have been found. But this is not sufficient evidence from which to conclude that it was ever numerous even in suitable localities. All we can say is that our uplands and mountains have been, from remote times, as now, suitable habitats for sheep, as the domesticated flocks that live in these places abundantly testify.

Turning to the bird life, there are only four species strictly confined to the Heather lands. These four are the Red Grouse (*Lagopus scoticus*), (Fig. 60), the Merlin (*Falco æsalon*), the Ring Ouzel (*Merula torquata*), and the Twite or Mountain

Cock. *Hen.* *Cock.*

FIG. 60.—THE RED GROUSE (*Lagopus scoticus*).

Linnet (*Cannabina flavirostris*). Formerly other species were frequent as breeders, especially the three Harriers, one of which, the Marsh Harrier, was locally known as the Moor Buzzard or Moor Hawk, proving that it occurred in sufficient abundance to merit a popular name indicative of its favourite haunts. The Buzzard, the Raven and the Black Cock were at one time inhabitants of the moors—the Raven being particularly numerous. Black Game—birds of woods rather than of heaths—bred near Commondale until 1847, and a few are still seen occasionally.* Doubtless in past centuries others, such as kites, eagles, herons, bitterns and the rarer marsh species formed a not inconsiderable part of the moorland avi-fauna; not that these species would be restricted to the moors, but their breeding and feeding haunts, being in the wilder and craggier corners of the dales, would lead them to adopt a more or less moorland life.

Other very characteristic ericetal birds are the Curlew, the Golden Plover, the Lapwing and the Snipe, and though regular visitors to, and breeders on the uplands, they are not confined to them, generally moving in the winter to the lower grounds and the estuaries of the coast. To describe their habits is superfluous, since this has been done a thousand times by ornithologists. The same remark applies to the Meadow Pipit (or "moor tahtling" in the local dialect), so extremely numerous all over the district from sea level to the highest point. It is one of the few birds that possess a complete altitudinal range. Occasionally the Quail nests upon the moors, and another species rarely seen but more frequently heard, especially near woods, is the Nightjar, whose "churr" on quiet summer evenings sounds far and wide.

Where ponds exist, Wild Duck and Teal will breed, as on Wapley Moor; but these species cannot be regarded as moorland birds. The same may be said of rare stragglers,

* Nelson, "Birds of Yorkshire," to which I am indebted for many facts adduced in this chapter.

Geese, Night Herons, Goshawks, Sand Grouse and others. Not belonging to the moors they call for very little attention at our hands, and though interesting from a faunistic point of view, are of no vital importance in the present moorland avi-fauna, whatever they may have been in the past.

The four moorland birds proper now demand further notice, though even these are often found away from their usual habitats. The Ring Ouzel is a summer visitor ; the Twite moves south in flocks, and is frequently seen on the coast and in marshes during the winter ; the bold blue Merlin generally leaves the moors for the lowlands in winter, and many perhaps leave the district in autumn, returning again in the spring ; the Red Grouse is the moor bird par excellence, feeding solely upon the ericetal plants and living on the uplands all the year round, save when in very wintery weather, being unable to obtain food beneath the frozen snow, it resorts to the fields and has even been seen on the seashore!

Universally distributed over the moors of Yorkshire, where it probably attains its largest size and finest plumage in Britain, the Red Grouse is usually considered to be a species peculiar to the British Islands, though very closely related to, and by some authorities regarded as a local race of the Willow Grouse or Ripa (*Lagopus albus*) of Scandinavia, from which it differs solely in the absence of a white winter plumage and in the presence of blackish brown flight feathers. Mr. Ogilvie-Grant, our greatest authority on game birds, regards it as one of the most variable birds in existence.* There are three types of male plumage—a red form, a black form, and a white-spotted form ; the first is found chiefly on the low grounds of Ireland, the west coast of Scotland and Outer Hebrides ; the second is typically developed on the moors of northern Scotland ; whilst the third is rarely found pure. The female, according to the same authority, has no fewer

* " Catalogue of Birds, British Museum," Vol. XXII.

than five distinct types of plumage—red, black, white-spotted, buff-spotted and buff-barred. Of these, the buff-spotted is the most frequent, the others being comparatively rare.

Mr. T. H. Nelson informs me that the usual types of colouration in Cleveland are the red and white-spotted forms, whilst occasionally other varieties occur—black, and black-breasted cocks, the hens being generally spotted. He also adds :—" There is a light form which is supposed to come from the west, and the keepers call this ' Lancashire Dun,' it usually appears in September or October. . . . I also think the birds are partly migratory."

Without going into details concerning the habits of this unique bird, it is sufficient to say that the eggs are deposited in April and May in a grass-lined hollow amongst the Heather. Being sheltered by the tall Ling stems the hen bird is not seen on her nest ; and in June 1901, when walking through the Heather at the head of Baysdale, I accidently stepped upon a Grouse sitting upon her eggs. As the bird rose without a sound from under my foot nearly all the feathers came out of her tail. The eggs proved to be on the point of hatching.

The Red Grouse belongs to a genus of birds limited in number and of circumpolar distribution, as will be seen from the following facts relative to the different species, and as represented on the annexed map (Fig. 61).

Willow Grouse (*Lagopus albus*).—North Europe, north Asia, North America and Greenland. A bird of the tundras.

Ptarmigan (*Lagopus mutus*).—Scotland, the mountains of Europe as far south as the Alps and Pyrenees, eastwards to the Ural Mountains.

Rock Ptarmigan (*Lagopus rupestris*).—Very closely related to the Ptarmigan, and in winter indistinguishable from it. Iceland, Greenland, Newfoundland, Arctic America, Aleutian and Behring Islands, Japan and north Asia as far west as the Urals.

Spitzbergen Ptarmigan (*Lagopus hyperboreus*).—Spitzbergen.

White-tailed Ptarmigan (*Lagopus leucurus*).—Only found towards the summits of the Rocky Mountains ; south to New Mexico ; north to Fort Halket, British America ; west to Oregon, Washington Territory, and British Columbia.*

On analysing these facts nothing very definite as to the centre of origin of the genus can be ascertained, except in so far that the birds must have originated at a time when land connections existed around the circumpolar regions, or otherwise their distribution is inexplicable, seeing that the species live in Greenland, Iceland, north Europe, and North America. Excluding the special Spitzbergen Ptarmigan, and uniting the Red Grouse with the Ripa, and the Ptarmigan with the Rock Ptarmigan, we find that the two forms occur in Europe, north Asia, and North America, where we meet also with a peculiar species, the White-tailed Ptarmigan of the Rocky Mountains. This seems to suggest a North American origin for this genus, but the inference is too uncertain to be of much value. Glancing at the other members of the grouse *family*—the Tetraonidæ —we observe that the Black Grouse (*Lyurus*) live in Europe and north Asia ; the Sharp-winged Grouse (*Falcipennis*) in north-east Asia ; the Capercailzies (*Tetrao*) in Europe and Asia ; the Canadian Grouse (*Canachites*), the American Capercailzies (*Dendragapus*), the Pinnated Grouse (*Tympanuchus*), the Sage Grouse (*Centrocercus*), the Sharp-tailed Grouse (*Pediœcetes*), the Ruffed Grouse (*Bonasa*) live in North America ; and the Hazel Hens (*Tetrastes*) in Europe and in in north and central Asia. Thus, no fewer than seven genera (including *Lagopus*) are found in North America as against four genera peculiar to Europe and Asia ; the number of species in America being fourteen and in Europe

* " British Museum Catalogue of Birds," Vol. XXII.

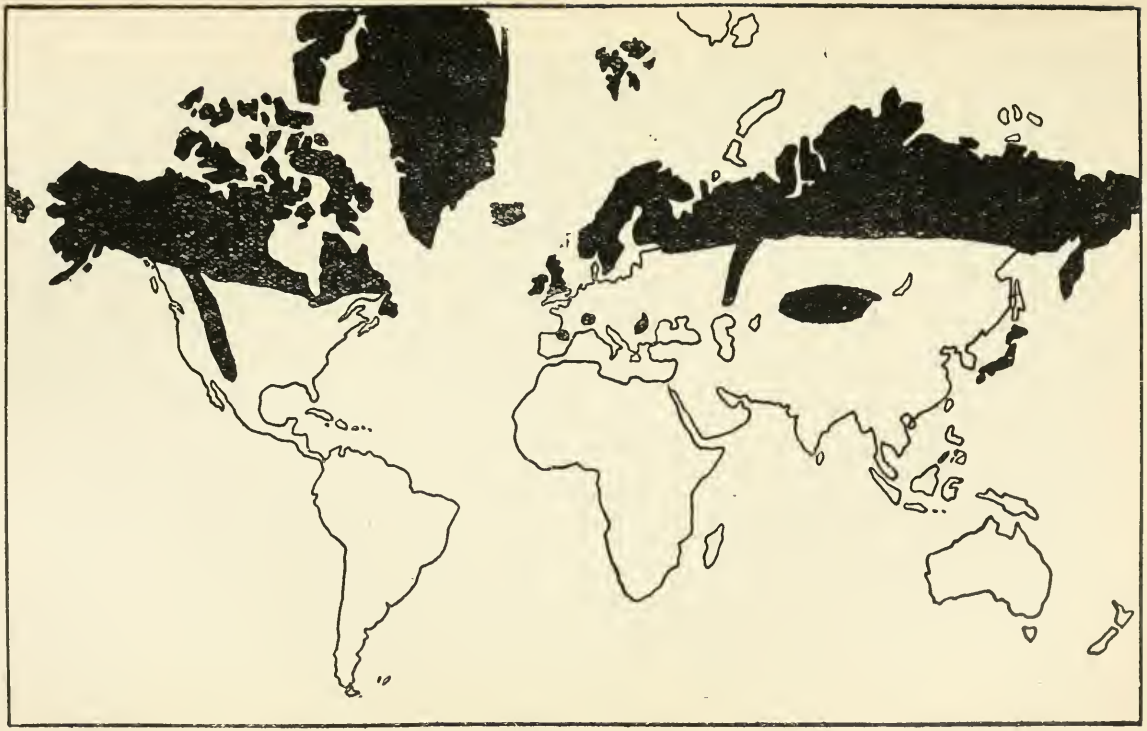


FIG. 61.—MAP OF THE WORLD, SHOWING THE DISTRIBUTION OF THE GENUS *Lagopus*.

eight, whilst nine occur in Asia. Amongst these, there are twelve species peculiar to North America, four are peculiar to North Asia, and three are peculiar to Europe (including the Red Grouse). The Ripa occurs throughout the circumpolar region ; the Rock Ptarmigan is found in North America and Asia ; whilst three of the group inhabit both Europe and Asia.

These facts seem to indicate that the original centre for the family was North America, and this confirms the supposed origin of Grouse (*Lagopus*). In this continent remains of the Sharp-winged Grouse have been detected in the Pliocene of Oregon, which proves that the modern genera had already arisen before the Ice Age. If, therefore, we suppose Grouse and Ptarmigan to have been evolved in North America, the genus gradually adapted itself to the on-coming cold of the circumpolar regions after the warm Miocene climates (revealed by the fossil floras of Greenland) were passing away. It is then that the birds would acquire their white winter plumage in adjustment to the Arctic conditions. The Ptarmigan with its sub-specific variety, the Rock Ptarmigan, spread westwards into Asia and thence into Europe, or eastwards to Greenland and Iceland into Europe by old land surfaces. The same may be said of the Ripa, which, since it also occurs in Greenland, must have entered that country either from North America or northern Europe. Land connections with north Europe in pre-glacial times led to the colonisation of Scotland by the Ptarmigan ; a colonisation accelerated by the advent of the Ice Age which would tend to spread these birds, together with the Willow Grouse, southwards. The complete glaciation of Britain caused them to pass still further south beyond the limits of the ice-sheets, and even into France, as is testified by their bones having been discovered in the cave of Bruniquel, near Montauban.* It is an open question whether these

* " Catalogue of Fossil Birds in the British Museum," by R. Lydekker, p. 134.

birds did not live throughout the Ice Age on the Eastern Moorlands, seeing that both the Willow Grouse and the close ally of the Ptarmigan, the Rock Ptarmigan, live in Greenland ; but whether they did so or not does not materially affect their history.

On the return of milder climatic conditions the birds retreated northwards, the Ptarmigan to be confined ultimately to the Scottish mountains in Britain ; but the Willow Grouse remained in England, became adapted to the special conditions of moorland life, and there originated the Red Grouse. It does not appear at all likely that this bird existed pre-glacially, its extremely limited British distribution suggests a post-glacial origin. Parallel cases are met with in the Orkney vole and the St. Kilda wren, which must have arisen in the respective islands since the Glacial Period. That the Willow Grouse could easily assume a purely moorland life may be inferred from its habits, living chiefly amongst Birch and Willow trees, where it feeds on the shoots, on moorland berries, and also on the shoots of Bilberry. We have already noticed the ericetal woods in the district which we are investigating, and so can easily understand how the changing Willow Grouse passed into the Red Grouse by adopting an ericetal instead of an arboreal life. When we treat of the insects of the moors we shall again find this community of Birch feeders and Heather feeders, the association of the two plants having caused various kinds of moths to pass from the one to the other.

During and immediately after the Ice Age, the British Ripas whose descendants were to become the Red Grouse, would practically be identical with the present continental species so far as plumage was concerned. That is to say there would be three moults—in spring, autumn and winter ; and in the latter season both cocks and hens would be more or less pure white in colour. With the changing life conditions of post-glacial times, however, and with the development of moors from the Arctic plant communities,

this white winter plumage would become unnecessary and even dangerous to its wearers. For white birds would be exceedingly conspicuous on the dark moorlands, thus rendering them easy victims to birds of prey. The elimination of the white winter plumage of the Willow Grouse would be forwarded by the process of natural selection, only the darker birds surviving. Doubtless the influence of the climate and the environment upon the colour of the feathers may have assisted in the formation of the present dark race ; but the transition from the white-plumaged Willow Grouse to the dark-plumaged Red Grouse though achieved in this way has produced further results that are very remarkable, and that emphasise the difference between the two species. The researches of Mr. Ogilvie-Grant have revealed the fact that the Red Grouse has only two moults in the year and not three as in the case of the Willow Grouse. Further, he has been able to prove by a careful study of the extensive series of specimens in the British Museum, that these two moults occur at different seasons of the year in the two sexes, viz., in spring and autumn in the hen, and in autumn and winter in the cocks—a fact "without parallel amongst birds even of the genus." The conclusions Mr. Ogilvie-Grant arrives at are as follows :—"The male has no distinct summer plumage, but changes in autumn and again in winter, retaining the latter plumage till the following autumn after the breeding season ; whilst the female has a distinct summer plumage complete by the end of April, and also a distinct autumn plumage, but never assumes a distinct winter garb, retaining her autumn plumage until the following spring."*

The dropping of a moult would always be an economy to the birds especially in the female, and any tendency to the omission of a moult would be of great advantage in the struggle for existence during post-glacial times. The three moults of the Ripa and Ptarmigan have evidently been

* Op. cit,. p. 38 ; which also see for descriptions of the complicated plumage.

acquired in adaptation to their conditions of life, and the birds were in all probability derived from ancestors with two moults, one in spring and the other in autumn. Hence the female Red Grouse with her spring and autumn moults has probably reverted not to her immediate ancestors, the Ripas, but to those remoter ancestors of the genus before it became Arctic in its habits. When the Red Grouse was being evolved under the ameliorating changes of post-glacial times, it would be an immense advantage to the hens to omit the winter moult ; and there must have been a tendency for some of the autumn feathers to be retained throughout the winter, a variation still shown by many of the autumn and winter feathers of the hen which are not cast but merely change colour. Hence by the natural selection of such variations which would be of great service to the bird, the winter moult has been gradually discarded and the autumn plumage made to last throughout the winter. The spring moult has been retained, however, on account of its adaptive necessity when the hen birds sit upon their nests amongst the moorland vegetation.

Male Grouse, in their assumption of a dark winter plumage after the autumn plumage, still retain the winter moult of their ancestors, the Ripas, the change of colour being facilitated by the extreme variability of the plumage, and by the direct action of the environment upon the colour of the feathers, co-operating with natural selection. Cock birds in North-Eastern Yorkshire, as already mentioned, are often spotted with white ; a feature which they have inherited from the Willow Grouse, for these white spots must be the last relics of the winter plumage. But how comes it that the dark winter plumage of the males is retained until the following autumn, and that there is no spring moult as in the female ? As the cocks possess this plumage throughout the spring and summer, and as we have no grounds for thinking it other than adaptive, we probably find one of the reasons for the omission of the spring moult to lie in

the circumstance that the winter plumage harmonises with the general tints of the moorland vegetation from winter to summer, when the pure Heather moors remain pretty much the same. Owing to its habits the cock bird does not require a special breeding dress to render him invisible amongst the plants as in the case of the hen bird. But this explanation is not sufficient, for how was the omission of the spring moult initiated? A clue to this problem we shall find in the character of the spring moult of the Willow Grouse and the past climatic conditions of Great Britain in Pleistocene times.

Directly after the Ice Age when the country was still Arctic, the British Ripas must have possessed in the male a tendency to retain most of their white winter feathers, as is the case with birds of the same species from high latitudes, in which all "the upper parts from the back of the neck remain white, merely interspersed here and there with a few summer feathers"*; whereas in the female the spring moult is always complete in every latitude. Here, then, we actually find that in the ancestors of the Red Grouse there would be a strong tendency towards an incomplete spring moult in the cock birds, which, with the amelioration of the climate, the darkening colour of the winter plumage, and the adaptability of this to the moorland vegetation in the spring and summer, would be useful to the bird under the changing conditions of life, and may well have been accentuated by natural selection until the summer plumage was dispensed with altogether.

Thus the Red Grouse merely accentuates in its remarkable changes of plumage traits exhibited by its allies, traits which under the varying conditions of Pleistocene ages may well have been fostered by natural selection to the advantage of the species. That the Red Grouse and the Willow Grouse are descended from a common progenitor is possible; but

* Ogilvie-Grant, op. cit. p. 41.

this common progenitor must have so closely resembled them as to be practically indistinguishable. In any case, the progenitor which lived in Britain just after the Ice Age must have possessed traits similar to those of the Willow Grouse, so that we may regard the latter species as the living representative of the ancestors of the Red Grouse.

We will conclude this account of the "moor birds" by mentioning that after their establishment in Britain, a small beetle, *Atomaria gibbula,* became adapted to live in their droppings! First noted in Perthshire, this beetle has been taken near Scarborough. The genus *Atomaria* is of the general European or Germanic facies, and the species in question has undoubtedly acquired its very special habits in post-glacial times. The droppings of the Grouse must exercise some effect on the moorland plants, but hitherto no observations have been made on this point.

Well-distributed over the Eastern Moorlands, the Ring Ouzel is in all respects the ericetal equivalent of the Blackbird. Arriving in spring, and possessing a pure white throat band which gives it a most handsome appearance, the Ouzel nests on the ground or in bank sides, and sings a much less melodious song than his relative. Judging from its distribution, which ranges as far east as the Volga in north Europe, and through Asia Minor to Persia in the south, we may conclude that it is perhaps a bird of Asiatic origin, since there are nine species of Blackbirds in eastern Palæarctic Asia and fourteen species in the Oriental Region lying to the south of this. Throughout its range, the Ring Ouzel is essentially a bird of hilly and mountainous districts, which are its primary habitats, that of living on moors being secondary.

The Twite occurs very sparingly over the moorland area, and closely resembles the common Linnet in its habits; but differs in being slightly smaller, in having a yellowish beak, and in the lack of those rosy colours which impart so much beauty to the lowland species. Its song resembles

that of a Redpoll more than that of a Linnet. The bird is obviously a Linnet adapted to a moorland existence. This species also appears to be of Asiatic origin, for not only does it range into Turkestan but several of its congeners are also more or less numerous in Asia.

The last bird of the moors which we have to consider is the Merlin, which like the preceding, breeds but sparingly in North-Eastern Yorkshire, owing to the incessant persecution to which it has been subjected. It feeds very largely on insects ; and one authority, Mr. E. T. Booth, states that it is very fond of the Oak Eggar Moths so abundant on heaths. Nesting among Heather and rocks, the Merlin lays eggs of the usual falcon type, and despite continual destruction still manages to hold its own in isolated localities. With regard to this species, it is quite impossible, either from its own distribution or that of the genus *Falco*, which is practically world-wide, to draw any definite conclusions as to its centre of origin.

The remaining vertebrate to be considered is the Viper or " hag-worm " (*Viperus berus*) reported from most parts of the Eastern Moorlands ; but it cannot be said to be at all abundant. People in the country state that " hag-worms " are common on the moors and elsewhere, but it must not be overlooked that the slow-worm is also called by the same name. Although specimens of the snake from various localities have been brought to me, I have only twice come across living Vipers on the moors within the last fifteen years, but it is not uncommon. A blackish snake-like tail will often be seen vanishing into the Ling ; but these tails usually belong to the Lizard which is abundant on most moors. The local designation of the Viper is used as a place name, the best known being Hagworm Hill, a glacial moraine, near Scarborough (Fig. 62).

Wandering over the moors at all seasons of the year, the naturalist cannot but be impressed by the paucity of bird and mammalian life. With the exception of the Grouse,

Photo by] FIG. 62.—HAGWORM HILL AND SEAMER BEACON, NEAR SCARBOROUGH. *[Godfrey Bingley.*

Photo by] FIG. 63.—SOLITARY ANT (*Mutilla europæa*) FROM MOORS NEAR ROBIN HOOD'S BAY. *[Frank Elgee.*

none of the species described forces itself upon the attention of the observer. Now, although game-preserving must have resulted in many species inimical to Grouse being destroyed, still even in the remote past a large number of birds could not have existed on the uplands. The boggy places are not very extensive ; yet it is only here that any increase could be expected. As insects generally are not numerous, of course insectivorous birds cannot become so, and consequently the number of individuals and species could never have been very great, and would soon reach a maximum. We may see that this is an important factor in determining the bird life when we compare it with that of a wood in which live Owls, Hawks, Jays, Woodpeckers, Tits, Flycatchers, etc. The Meadow Pipit is the only really insectivorous bird found commonly on the moors, the Twite subsisting on a mixed diet of seeds and insects.

In winter, moorland bird life falls to a very low ebb. Except for the presence of an occasional Grey-back Crow and the ever present Grouse, no birds are to be seen. With the return of spring the marsh birds revisit their breeding haunts and enliven the bleak uplands with their cheerful notes throughout the summer. Cuckoos will be heard calling over moor and dale ; and when evening approaches the " churr " of the ghostly Nightjar resounds over the wild moorlands. All leave towards the autumn, when, however, Blackbirds and Thrushes quit the valleys to feed on the Bilberries and impart a flickering touch of avian life to the moors before the desolation of winter.

CHAPTER XV

INSECT LIFE ON THE MOORS.

THE paucity of vertebrate life on the moorlands is in some measure compensated for by the comparative richness of the invertebrate life which depends more upon the vegetation, has been less interfered with by man, and consequently must have retained its characteristics for a long period. The words " comparative richness " are used advisedly, because contrasted with the invertebrate fauna of woods or lanes, that of moors is limited, both in the number of kinds and in the number of individuals, though its interest is equal to, if it does not exceed, that of other faunal associations.

The insects alone of all the invertebrates that find a home upon the moors have been sufficiently investigated to render an account of them possible, and of this great class of animals the Lepidoptera (butterflies and moths) are of the most value to us, owing to the assistance they furnish in confirming conclusions regarding the history of the moorland flora. Hence this part of our subject will deal largely with them, though first we must glance at other groups so far as they have been studied in the district.

It may be noted that the moors possess no molluscan fauna except the Black Slug (*Arion ater*), a species abundant in many habitats, and ranging from sea level to the highest point of the district, where it may be frequently seen creeping over the black peaty soil. Undoubtedly the moors are extremely unfavourable to snails, probably owing to the humic acids in the soil and the nature of the vegetation. This marked absence of molluscs is in striking contrast to their abundance in woods and on sand dunes.

Insect Life on the Moors

In Chapter III. reference was made to the probable influence of ants in distributing the seeds of Furze and other ericetal plants, and now we must notice these insects more closely. The most interesting species from our point of view is the Wood Ant (*Formica rufa*), which, strictly speaking, is not a moorland insect at all. Notwithstanding its sylvan habits, however, this species is abundant in Baysdale and some of the tributary valleys—Great Hograh especially—its characteristic ant-hills being found scattered amongst the Heather on the slopes. On moors far away from wooded ravines the species is not found, but in valleys where no woods exist it will be met with. Planted woods of coniferous and deciduous trees never contain the Wood Ant, and its haunts show that it was formerly a denizen of much of that ancient woodland now converted into moor. Hence we may conclude that wherever the ant-hills of this species occur on the moors, these latter have been more or less clothed with trees ; and its occurrence further confirms the conclusion previously reached that most slopes were formerly wooded. Doubtless the species is of fairly wide distribution in North-Eastern Yorkshire, but I have only come across it in Baysdale, on grassy roadsides in Newton Dale, and in Riccal Dale. The insect is easily distinguished from other ants by its larger size and red and black colours.

Other species of ants are even more numerous on all parts of the moors, their nests being chiefly situated under stones, and on some stony heaths nearly every boulder shelters a colony. The most abundant of these is the Red Ant (*Formica fusca*) ; next stands the Black Ant (*Lasius niger*) ; whilst of rarer occurrence is the Yellow Ant (*Lasius flavus*), which usually frequents grassy moors and slopes. Some nests of the Red Ant persist for a long time under the same stone—as long as from fourteen to twenty years. Towards the month of August this species swarms ; and in hot September weather winged males and

females fly about in thousands, and creep over the sandy roads in vast numbers.

By far the rarest of all the moor insects is the so-called Solitary Ant (*Mutilla europæa*), (Fig. 63), the representative of a group of Hymenopterous insects—the Mutillidæ, remarkable for their winged males and wingless females, their unsocial habits, and parasitic instincts. Until recent years this species was thought to be restricted to the south of England; but in 1903 a specimen was taken on the moors near Scarborough, and recorded by the late Rev. W. C. Hey in "The Naturalist" for that year. In August, 1904, when studying the glacial geology of the moors behind Robin Hood's Bay, I accidentally found a second specimen on the summit of one of the most impressive relics of ice-action in that area, Brown Rigg (Fig. 64). A third was found on the Peak Moors by Dr. J. W. Fordham, of Sheffield, in 1905. The three specimens were all females. In appearance the insect is quite unmistakable, having a black head, red thorax, and black abdomen; the latter has three silvery or golden bands, one unbroken near the junction of the thorax and abdomen, and two broken bands situated near the extremity of the insect. In its metamorphoses, *Mutilla europæa* is parasitic on certain species of wild bees, in the nests of which it deposits its eggs, and on the grubs of which its own larvæ feed. Hence they differ profoundly from true ants in every way, and naturally constitute with their allies a very distinct family of parasitic Hymenoptera.

When this insect was found it was thought that it was the first reported occurrence of the species in the north of England; but I have since discovered a record in the "Transactions of the Natural History Society of Northumberland and Durham" for 1855, where the Solitary Ant is stated by Bold, in his list of Aculeata Hymenoptera of the two northern counties, to have been taken occasionally on the sand-hills near South Shields. Before the Yorkshire specimens were captured, Colchester in Essex was considered

Photo by] FIG. 64.—JUGGER HOWE DALE LOOKING SOUTH. *[Godfrey Bingley.*

(Brown Rigg in the left background).

the most northerly latitude for this insect in Britain. It has been chiefly found in the sandy regions of Surrey, Dorset, Hampshire and Berkshire ; whilst it occurs throughout the whole of Europe from Sweden, Finland and Russia to the extreme south. It also ranges into north Africa, Asia Minor and Japan.* The discovery of this insect in North Yorkshire is one of those unexpected entomological events which show that many rare forms may yet be found by the zoologist in this comparatively unexplored district.

In attempting to explain its presence in North-Eastern Yorkshire, attention must first be directed to the distribution of the genus in Europe ; this is shown upon the following map (Fig. 65), where every black dot corresponds to a species of Mutilla. We see at a glance that the head-quarters of the genus are in the south of France, and that the further north we go, the rarer it becomes. In France, and especially the south, there are thirty species ; in Germany, twelve ; in Sweden, two ; and in Finland, two. Russia has eleven species, some of which occur in the neighbourhood of Elizabethgrad, Italy has nine, and Greece has three species. Two kinds of Solitary Ant occur in Britain—the one with which we are dealing, and *Mutilla ephippium*, which is restricted to south-eastern England. From these data we may infer that the Mutillidæ have travelled over Europe from the south ; and this inference is supported by the fact that in north Africa over twenty species live in Algeria and over twenty in Egypt, seven species being common to Europe.†

The group is certainly not of European origin since over one thousand species are known from all parts of the world, chiefly from the tropical regions of Africa, Australia, South

* E. André, " Species des Hyménoptères d' Europe et Algérie, VIII." p. 240 (1900). Kindly communicated by Mr. G. Meade-Waldo, assistant in the Zoological Department, British Museum.

† Catalogue of Hymenopterous Insects in the British Museum, part 3, Mutillidæ and Pompilidæ, by F. Smith, 1855. Also Descriptions of New Species of Hymenoptera in the British Museum, 1879.

America and Asia. Such a distribution bespeaks a very ancient origin for this unique family, which perhaps goes back to a time when the configuration of land and water must have been entirely different, otherwise its range is inexplicable. In the Americas, as in Europe, the further north we go, the less numerous do the species become, as the following figures indicate* :—

South America	.. .. ..	133 species
Central America	.. .. ..	25 ,,
North America	.. .. ..	15 ,,

It must, I think, be concluded from these facts that ages ago, the Mutillidæ originated in sub-tropical and tropical lands whence they have spread over the greater part of the earth. At what exact period the two British species first entered this country we have absolutely no means of ascertaining. All that can be ascertained is that it may have taken place during the Tertiary period. As the Ice Age came on the ants would be driven southwards, and probably became extinct throughout the country ; but there is a possibility that the commoner species managed to struggle through the age of cold on the ice-free oasis of North-Eastern Yorkshire. Startling as this suggestion may appear after what we have just said concerning its tropical origin and its parasitic habits, it becomes less so if we bear in mind the following facts :— the ant lives in the severe climate of Finland ; another species, *Mutilla frigida*, exists in Arctic America in the vicinity of the Great Bear Lake † ; and humble bees occur in Grinnell Land. Hence it is not unlikely that the Solitary Ant together with its hosts may have survived the Ice Age on the driftless area. At the same time it may also have survived the same rigorous period in the unglaciated regions of the south of England whence it has spread northwards into Essex.

The foregoing explanation certainly accounts for the

* Op. cit. .
† Op. cit. 1855, p. 61.

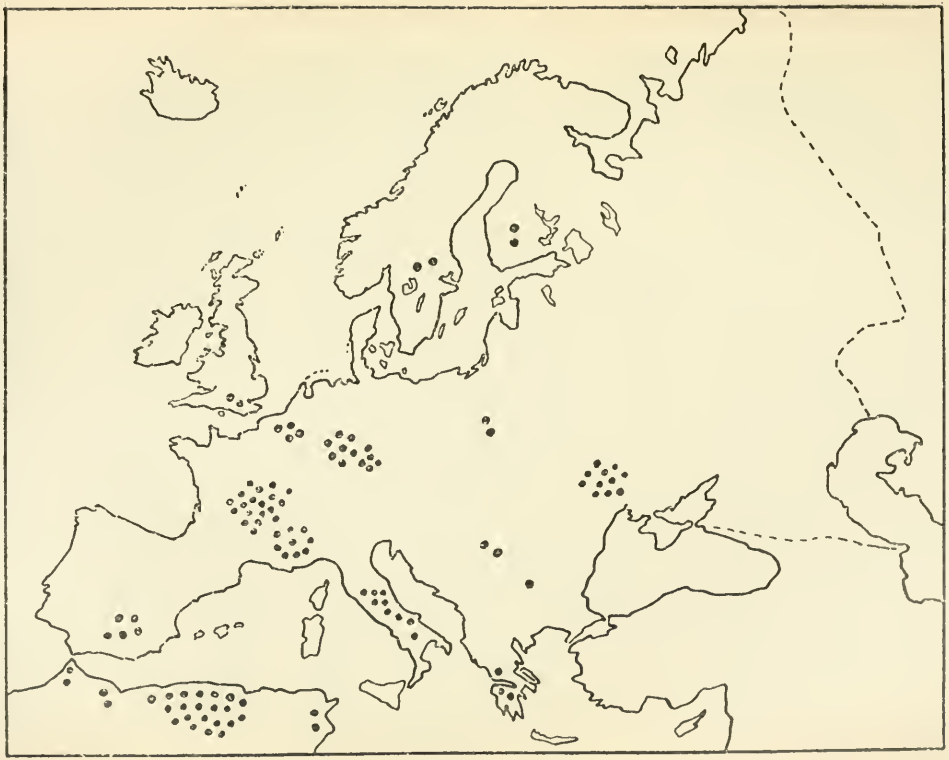


FIG. 65.—MAP SHOWING DISTRIBUTION OF THE GENUS *Mutilla* IN EUROPE.

distribution of the Solitary Ant in Great Britain, and was advanced by me before the Durham record was discovered.* This record greatly alters the aspect of the problem, for we now have to explain its occurrence at South Shields. Let us assume that this insect was exterminated in Britain by the Glacial Period; the ant must then have re-entered the country from the Continent in post-glacial times, and spread northwards to Yorkshire and Durham during the warmer Forestian epoch, since which period it has become extinct in the intermediate area by colder and wetter conditions, or by the destruction of suitable sandy habitats. As yet we know of no record of its existence between Colchester and the Eastern Moorlands; but if the insect does occur in that area, its presence on our moors may be accounted for by continuous dispersal northwards since the Ice Age.

Further, it may be pointed out that the Solitary Ant, occurring as it does on the eastern sea-board, may be a relic of direct land connections with the Continent in post-glacial times, as was suggested in the case of the rare plants of the south-eastern area. It is certainly noteworthy that this essentially southern insect should be found in the same neighbourhood as the plants; and this curious commingling of northern and southern forms suggests the same commingling observable in the Pleistocene mammals, and lends weight to the glacial survival theory. In announcing the discovery of *Mutilla europæa*, the Rev. W. C. Hey remarks:—"It is strange that the identical moor upon which this Mutilla was found has also yielded to me many examples of insects of a much more northern type than those usually found near Scarborough."

But in whatever way the occurrence of the Solitary Ant on the Eastern Moorlands is to be accounted for, there can be little doubt that it originated in pre-glacial times from southern Europe.

* *Naturalist*, 1907.

Insect Life on the Moors

Nearly one hundred species of beetles live upon the moors, but the majority are not endemic, and exist in various other situations. This arises from the circumstance that they are not so dependent on plants for their food, are more varied in their habits, and are, consequently, more adaptable to all kinds of habitats. Carrion beetles, dung beetles, water beetles and carnivorous beetles constitute groups of species more or less the same everywhere, in woods, lanes, fields, or moors. Throughout these general assemblages of species will be found those peculiar to special haunts, and a few of these exist upon moors. True ericetal species include those which subsist upon the heath vegetation, and those of carnivorous habits usually found on mountains and high hills.

The most conspicuous, and at the same time a very abundant insect, is the green and blue Tiger Beetle (*Cicindela campestris*), which flies over the moors on sunny days from the beginning of April to the end of September. Although such a characteristic element in the insect life of the uplands, its presence is primarily due to the light sandy soils into which its carnivorous larvæ can burrow, and not to the fact that the land is clothed with Heather. As Dr. R. F. Scharff has shown, this species probably originated in south-east Europe, for in that part of the Continent the genus is very highly developed.*

Ground beetles occur freely; the Carabidæ being represented by the brilliant *Carabus nitens* and the more soberly coloured *Carabus arvensis*, species that are rarely, if ever, found away from the moors at any rate in this district. The black beetles of the genus *Pterostichus* will be found under most stones; and several of the species are only known to inhabit high moorlands, *P. æthiops* and *vitreus* being instances. The late Rev. W. C. Hey, of East Ayton, recorded a specimen of *Pterostichus lepidus*, a bronze-coloured insect from Sawdon and Ebberston Moors, up to the present

* "History of the European Fauna."

its only recorded Yorkshire habitat. Unless this insect entered the district in pre-glacial times, and survived the Ice Age on the driftless area, it is difficult to understand how it could come to occupy its present home, if the moors are its only Yorkshire station. But while reserving an account of the relation of moorland insects to the Ice Age until we treat of the Lepidoptera, we must draw attention to the fact that this scarce local beetle has been detected in the south-eastern area of the moors, where nearly all the other biological rarities of North-Eastern Yorkshire dwell.

We must here mention the occurrence of a northern beetle, *Miscodera arctica*, on Stanghow Moor, in North Cleveland. Found there in 1892 by Mr. M. L. Thompson, the well-known Yorkshire coleopterist, the species has lately been discovered in abundance on the Grangetown slag banks near the mouth of the Tees.* This small and peculiarly-shaped bronze coloured beetle is confined to north Europe as far south as Stettin and Dantzig, and also occurs in the Alps. An insect evidently originated in, and adapted to, cold climates, its rarity in North-Eastern Yorkshire is due to the low elevation of the hills and comparative milddness of the climate ; for elsewhere in Britain it dwells on the high mountains of the north, and in Scotland. By flourishing in such a strange haunt as slag banks, this insect proves the remarkable adaptability of its class, and that the species in question is not dependent on moors for its existence.

Small ground beetles of the genus *Bembidium* are represented by several species, of which we may take *Bembidium nigricorne* and *mannerheimi* as instances. Living chiefly under stones they belong to a group of ancient origin, for their congeners are scattered widely over the Continent and can scarcely be traced to any definite centre of origin.

The genus *Bradycellus*, typical of mountains and moor-

* *Naturalist*, 1910.

lands, has three forms in our moorland area. The district is evidently too low for mountain species to be at all numerous, though further research may increase their number.

Seeing that plants are so abundant on the moors, we should have expected peculiar types of weevils to be abundant, but singularly enough there appear to be only three species. Two of these belong to the genus *Strophosomus*—*S. retusus* and *lateralis*, both small and obscurely coloured; whilst the third, *Ceuthorrhynchus ericæ*, is still smaller, being less than an eighth of an inch in length and possessing a well-defined rostrum. These weevils probably mine the stems of the plants, and, moreover, seem to be the only insects on the moors which have adopted this mode of life. Why plant-feeding beetles should be so comparatively scarce forms a problem by no means easily answered. A brilliantly-coloured jumping beetle, *Haltica ericeti*, lives upon plants and is of an oval shape with green or blue tints, and is of fairly frequent occurrence.

Special types of water beetles belonging to the genus *Hydroporus* live amongst Sphagnum; whilst dung beetles, the *Aphodii*, have two species, *Aphodius fœtens* and *lapponum*, peculiar to moors and living in sheep droppings.

Little can be said concerning the origin of the moorland Coleoptera, for the reason that the majority of the species are included in genera of almost universal distribution. *Ceuthorrhynchus*, *Bradycellus* and *Haltica* are south and mid European in their range. The restriction of *C. ericæ* and others to England and Germany suggests their evolution in that area from the wide-spread groups to which they belong. *Strophosomus* is distinctly concentrated in south and south-west Europe, and the two moorland species may therefore be of southern origin. As the moorlands arose, beetles would quickly settle on them; some forms would be differentiated into new species, others would retain their old characteristics and become even more universally distributed and dominant.

CHAPTER XVI

INSECT LIFE ON THE MOORS—(*Continued*).

I.

IF the origin of the coleopterous inhabitants of the moors is very vague and the number of their peculiar species small, the same cannot be said of the Lepidoptera, which not only exceed the beetles in number but also possess a history that can be traced with some distinctness and that throws some light on the origin of the flora. Let us, therefore, examine these insects, and enter upon the last of the problems to be discussed in these pages.

Before considering the history and origin of the Lepidoptera of the moors, it will be well for us if we review briefly their succession throughout the year, since this will enable us to convey some idea of the habits and appearance of the different species. Here also may be included a few further observations upon the entomology of the moors.

Insect life begins to stir in March, when, on sunny days, the hairy larvæ of the Fox Moth (*Bombyx rubi*) roam over grassy spaces in search of suitable nooks in which to spin their cocoons and to pupate after their hibernation. In similar situations, towards the end of the month, a small greyish Geometrid moth, the Mottled Grey (*Larentia multistrigaria*), is not infrequent, resting on grass tussocks during the day and flying in the evening. Occasionally they will be found impaled upon Furze thorns, a death probably due to accident, for there are no butcher birds to commit such deeds.

In moorland Birch woods, the Yellow Horned Moth (*Cymatophora flavicornis*) occurs freely throughout the month, resting low down upon the trunks and branches where its

colours harmonise with the bark. In sunny weather, a small black sawfly, which probably lives upon Heather in the larval state, is quite a characteristic feature of the insect life of the uplands in March.

These species continue upon the wing during the greater part of April towards the end of which they are joined by the Emperor Moth (*Saturnia pavonia*), a large species with peacock-eye-like markings on each wing (see coloured plate). It flies in an erratic manner and with great rapidity on sunny days, and sometimes the males are so numerous that scores may be seen in the course of a day. The female is more sluggish, and may be found resting upon moorland plants. Usually these females have deposited their eggs and are in a dying condition. Larvæ which have been hibernating become more abundant in April, and include those of such species as the Oak Eggar (*Lasiocampa quercus*), with its brown hairs and black velvety bands; the Moor Carpet Moth (*Larentia cæsiata*), which is green with yellow and red V-shaped marks on the back; and the Heath Rustic (*Agrotis agathina*), which is greenish brown. On swiddens, the little black *Phycis fusca* swarms, flying over the charred gouldens and settling upon them, whilst the brilliant blue and green scintillations of the Tiger Beetle catch the eye as the insects fly over sandy banks and spaces. Ground beetles appear in some numbers during April, the most noteworthy being *Carabus nitens* with its corrugated metallic green elytra bordered with crimson, its crimson thorax and copper-coloured head. It seems to be at home on all kinds of moors, from the driest to the wettest, for I have observed it on grassy commons and on May Moss.

With the advent of May insect life on the moors begins to attain a maximum which continues until August. The Emperors are on the wing throughout this month, but in steadily diminishing numbers until they finally disappear. Several very characteristic members of the ericetal Lepidoptera now wing their way over the Heather, the commonest

of which is the Heath Moth (*Ematurga atomaria*), a species universally distributed over the Eastern Moorlands. As you walk through the Heather this moth flies out continually, and is quite unmistakable in its white and brown colours (see plate). Amongst dead Bracken fronds, the Brown Silver Lines Moth (*Panagra petraria*) is numerous, and its colours harmonise to a certain extent with the decayed fern leaves upon which it rests. If the tops of Heather plants be carefully examined, light cocoons of a very delicate fabric may often be observed. These belong to the Ruby Tiger Moth (*Spilosoma fuliginosa*), an insect which in North-Eastern Yorkshire appears to be restricted to the moorlands, though this is not the case in other parts of the country. Emerging from the cocoon in a week or a fortnight after the larva has pupated, the Ruby Tiger Moth is a very beautiful insect, possessing semi-transparent wings of a sooty hue tinged with rose. If we raise a reddish and black moth out of the Heather towards the end of May, the probability is that it is this species which we have disturbed (see plate). Another moth often seen upon the moors though not by any means peculiar to them is the handsome yellow and black Wood Tiger (*Nemeophila plantaginis*), which flies with great rapidity and impetuosity at some height over broken and wooded slopes. In May, the Little Yellow Underwing (*Anarta myrtilli*) begins to appear about the end of the third week (see plate). By taking up a position near a mass of Purple Bell Heath, we may observe these pretty little moths visiting the flowers; but all that can be seen of one in flight is a greyish-yellow object moving swiftly a few inches above the plants. The flowers of the Heath are also greatly favoured by bees, which, in their impatience to reach the nectar, often bite a small hole at the base of the corolla.

Another May Noctuid moth (*Hadena glauca*), rests upon stones, trees, and Heather, whilst a pretty mottled Tortrix (*Tortrix politana*) occurs in many parts of the moors. The

Small Heath (*Cœnonympha pamphilus*) and the Green Hairstreak Butterflies (*Thecla rubi*) are also on the wing in May; the former nearly everywhere, the latter only where Bilberry prevails (see plate). Last but not least of the May moorland Lepidoptera is the Light Knot-grass Moth (*Acronycta menyanthidis*), which, appearing towards the end of the month, is to be found upon sandstone boulders or drystone walls, where its grey and whitish tints blend with the colours of the rock and lichens. It is not a common species on the Eastern Moorlands, but occurs in the neighbourhood of Danby (see plate).

Many of the May Lepidoptera fly throughout June when they are re-inforced by other species the chief of which is the Oak Eggar Moth (*Lasiocampa quercus*), whose strong dashing flight in bright sunshine closely resembles that of the Emperor Moth. At dusk, female Fox Moths appear on the wing, and fly steadily a few feet above the vegetation, though the males dash wildly about during the day. Several Geometrid moths are in evidence this month, especially the Heath Pug (*Eupethecia nanata*), which is abundant on most moors (see plate). More local is the Smoky Wave (*Acidalia fumata*), a small whitish grey northern insect, often found on high mountains. The Grey Scalloped Bar (*Scodiona belgaria*) frequents some moors, and may in suitable habitats be seen in numbers either at rest upon the ground or Heather during the day, or flying just after sunset. I have seen scores of this species on the wing near Kempswithen; its feeble irregular flight combined with its conspicuous white colours makes it an unmistakable species (see plate). Where Gorse grows the Lead Belle Moth (*Eubolia palumbaria*) is not rare, and where the Milkwort flourishes a small purplish green moth (*Phytometra viridaria*) dashes about in warm sunshine. The detached wings of several of the larger moorland moths may frequently be observed lying on the ground in June, and indicate that the Nightjar or Merlin has been having a good meal of the bodies to which these wings once belonged.

July is characterised by the abundance of three species—

the Wood Swift (*Hepialus velleda*), the True Lover's Knot (*Agrotis strigula*), and the Moor Carpet (*Larentia cæsiata*, see plate). The first is found amongst Bracken or at rest upon stone walls; the second loves to creep amongst the Heather; whilst the third, with its finely mottled grey, black and white wings, is perpetually rising from the moorland plants and indulging in short flights before again seeking shelter. It is also extremely abundant upon stones and walls. On windy days the sheltered sides of drystone walls sometimes swarm with moths; and one of the best methods of insect hunting on the moors is to travel along these walls at all times of the year, examining every ledge and cranny likely to harbour insects. A peculiarity of the last-named species is that they fly out of the Heather by the roadsides some distance ahead of the observer. It would seem from this that they are able to detect the approach of anyone either by sound or other means. This view appears all the more probable when we remember that owing to the structure of their antennæ insects are far more sensible to air currents, odours and sounds, than higher animals.

In August, moth life begins to wane, though a considerable number of species may still be met with. At night the rare Heath Rustic (*Agrotis agathina*) is on the wing, and during the day the purple Moorland Silver-Y (*Plusia interrogationis*) flies rapidly over the Heather bloom (see plate). Amongst Bilberry, particularly where it grows under trees, the moorland form of the so-called July Highflyer (*Hypsipetes sordidata*) swarms at the beginning of the month (see plate). The Heather bloom being now at its best, many non-ericetal Lepidoptera frequent it for nectar; during the day, Tortoise Shells and Red Admirals visit the moors; at night, numerous Noctuæ and Geometræ, some of them rather rare. Larvæ of the Emperor Moth are now numerous, and with their brilliant green bodies ornamented with black bands and yellow tubercles, they delight the eye of all who see them for the first time. A pretty sight may be seen on the

The specimens are from North-Eastern Yorkshire.

Fig. 66.—MOORLAND BUTTERFLIES AND MOTHS

Insect Life on the Moors

Mosses when scores of Large Heath Butterflies (*Cœnonympha davus*) flit jerkily over the bog plants, the light silvery margins of their wings being very conspicuous (see plate). On grass moors, that destructive pest the Antler Moth (*Charæas graminis*) swarms during August, and very swiftly skims over the grass, usually in the forenoon.

Insect life on the moors falls to a low ebb in September ; most of the August species have disappeared, whilst only two further noteworthy moths remain to be mentioned. Towards four o'clock on quiet afternoons, a yellowish Geometer (*Cidaris populata*), flits about in abundance (see plate). On sunny slopes the Small Copper Butterfly (*Polyommatus phlæas*) is much in evidence ; but perhaps the most interesting species is the Bilberry Moth (*Cloantha solidaginis*) which feeds upon Bilberry in the larval state and which pupates under ground. Upon the emergence of the imagines in September they usually creep up the tree trunks beneath which the food-plant grows. They bear a most striking resemblance to a piece of twig projecting from the bark. In colour the moths are greyish, with lighter or darker markings. When at rest, the forewings are folded closely round the body, and this is raised above the bark of the tree trunk. In this position the insects remain motionless, their likeness to twigs being almost perfect. Two spots on the wings also aid the deception by their resemblance to small knotty rings, as if smaller pieces of twig had been broken off close to the main stem. As may be imagined this moth is by no means easy to find, and several hours can be spent in searching for it without success (see plate).

Two observations may fitly close this review of the succession of insect life on the moors. I once noticed hundreds of a peculiar species of Daddy Long-Legs (*Tipula sp.*) amongst the Cotton Grass on Stony Ridge in September ; and again, when on Murk Mire Moor on a misty day in October, I saw scores of ichneumon flies, with sickle-shaped yellow abdomens, on the wing. These parasites desposit their eggs in

the larvæ of the Fox and Oak Eggar Moths before they hibernate, as the ichneumons do not live throughout the winter.

In investigating moorland insects distinction must be made between stragglers to the uplands and residents on the uplands, for many lowland species manage to ascend to the highest points. I have seen the Angle Shades Moth (*Phlogophora meticulosa*) in November at heights of 1000 feet on Kildale Moor, and that ubiquitous species the Yellow Underwing (*Triphæna pronuba*), both of which live on plants not found on the moors proper. Conversely, a few cases are on record of true moorland insects occurring in the lowlands. The Cotton Grass Moth (*Celæna haworthii*) has been found in Middlesbrough, and the Emperor Moth (*Saturnia pavonia*) has been caught at the electric lights of the ironworks. Facts such as these indicate movements on the part of moths for purposes unrecognised in the present state of our knowledge of the migrations of insects.

The most remarkable feature of the entomology of the moors is the rarity of stem and root-feeding larvæ, and butterflies. Most plants have insects which bore into their tissues, the Scots Pine being particularly subject to this mode of attack. Not so with the true heath vegetation—the Ling, Bilberry, Crowberry, etc.—for if we omit one or two small species such as the Heather Weevil (*Ceuthorrhynchus ericæ*) amongst beetles, and Haworth's Moth (*Celæna haworthii*) amongst Lepidoptera, which lives in the stems of the Cotton Grass, there is no other species of stem-boring insect to be found upon the moors. Considering the fact that such extensive regions are clothed with Ling, it seems very singular that so few species should have adopted this habit. Root-feeding grubs occur on moorland grasses; but the most noticeable feature in peaty soil is the absence of any forms corresponding to those which are so abundant in woods and fields. Now one result of the dearth of subterranean life is that the peaty soil is far less disturbed than it otherwise would be; a fact already commented

upon in the chapter on the fat moors, and here, as in the case of the mollusca, the humic acids appear to be injurious to most larvæ.

With regard to butterflies only three species occur numerously on the Eastern Moorlands, and of these the Green Hairstreak (*Thecla rubi*) and the Small Heath (*Cœnonympha pamphilus*) thrive in other situations. No European butterfly in the larval state feeds upon Heather or Heath; and there is only one genuine ericetal butterfly in North-Eastern Yorkshire, and that is the Large Heath (*Cœnonympha davus*), a species not uncommon on the Mosses and in other boggy localities. The almost entire absence of insectivorous birds shows clearly that the insect fauna of the moors is poorer than that of woods.

The intimate relationship subsisting between plants and insects is one of the most familiar facts in natural history. We find it illustrated in numerous ways, one of which is very clearly displayed by the Lepidoptera. Almost without exception the whole of this great order live in the larval stage upon plants; such exceptions as occur only serving to emphasise the general rule. Though many species feed indiscriminately upon a variety of plants, it more frequently happens that a particular moth or butterfly is restricted to one kind of food-plant, or, as is often the case, to a group of closely related kinds. Furthermore, several species live upon the same food plant, all of course quite independently of one another. Whilst one caterpillar feeds in the seed heads, another browses upon the leaves, a third attacks the roots, and yet another bores into the stems. The perfect insects issuing from these varied larvæ may belong to the most diverse families of the order, and may be of very different habits. Still, however diverse the species are, the circumstance of their all being ultimately dependent upon a special plant gives them a common attribute which must be of importance where their origin is concerned.

These considerations will enable us to define with some

precision the exact meaning of the term ericetal Lepidoptera. In it we include those moths feeding in the larval stage upon Heather, the two Heaths, Bilberry, Cowberry, Cotton Grass and Sweet Gale. By far the greater number of insects which live upon them are found nowhere else but on moors, though some manage to thrive upon other plants. A few Lepidoptera occur upon Crowberry, Bearberry, Potentilla, etc.; but these are of less importance as compared with the group just mentioned. Moths subsisting on moorland grasses have been purposely excluded because they belong to an assemblage of forms of almost universal occurrence—the grass feeders—which require special investigations to disentangle their elements. No important species are omitted by this treatment, and all stragglers to the moorlands are excluded.

Earlier chapters have made us familiar with the plant associations of the botanist, in which one or more species may be dominant, others sub-dominant, and some merely sporadic. Such a grouping of plants suggests an analogous grouping of the insects which feed upon them. Thus, all the insects which infest the Pine cannot be otherwise regarded than as intimately associated with one another. In other words they form a biological association of insects. Similarly with the Lepidoptera of the moors. Here we find an association of moths, some species being abundant, others local, and some rare; and the likeness to the plant association is still further enhanced when it is noted that these insects can be divided into sub-groups dependent upon particular kinds of plants, Ling, Bilberry, or Bracken. Such a community of insects in comparison with those peculiar to the Oak, Birch, or Pine, must present very different aspects of habit, distribution and origin.

As is well-known, moths do not always occur where their food-plants grow, but, generally speaking, a plant's geographical distribution must exercise a considerable influence upon them. Some species flourish throughout the entire range of the plant; others, though coterminous with the

plant's range, are nevertheless local; whilst other species only exist in a very limited part of the area occupied by the plant. It must be obvious, however, that the distribution of the various forms subsisting upon one kind of plant or allied group of plants, ought to present features of some significance when contrasted with one another; and the geological history, past migrations, and present life conditions of plants must have had an important effect in determining not only the history of their insect dependents, but also to some extent the character of these latter.

An adequate discussion of the moorland Lepidoptera is only possible when all the British and Continental species are reviewed. At the very least over 120 species occur throughout Europe, whereas in North-Eastern Yorkshire only about forty species have up to the present been detected. Hence while the ensuing account of the moorland moths and butterflies will be illustrated by species found in this district, the general conclusions regarding their origin are drawn from an examination of the association in its European ensemble (see Appendix).

The heath-frequenting Lepidoptera may be divided into the following sections :—

Species dependent upon Heather and Heath, or Callunal Association.

Species dependent upon Vaccinium, or Vaccinial Association.

Species dependent upon Sweet Gale.

Species dependent upon Cotton Grass.

Species dependent upon Bracken.

By far the greater number of Lepidoptera occur on Ling and Bilberry, as will be seen from the annexed figures :—

Callunal Association ..	..	about 49 species.
Vaccinial Association..	..	,, 52 ,,
Myrica Association ..	..	,, 6 ,,
Eriophorum Association	..	,, 7 ,,
Pteris Association ..	..	,, 3 ,,

Few of these insects feed on plants not belonging to their own association, though a certain amount of intermixture exists. Thus, the Moor Silver-Y Moth (*Plusia interrogationis*), a beautiful insect with purplish forewings, and not uncommon on the Eastern Moorlands, usually feeds as a caterpillar upon Heather, but it does not disdain Bilberry; whilst the Moor Carpet Moth (*Larentia cæsiata*) has a similar though obverse peculiarity, favouring Bilberry, but often found on Ling. Again the Light Knot-Grass Moth (*Acronycta menyanthidis*) in North-Eastern Yorkshire lives upon Heather; but on the Continent it is said to feed on Sweet Gale, Cranberry, etc. Further, a few species pass entirely off moorlands and join insects in woods and lanes. Among these may be mentioned the Emperor Moth (*Saturnia pavonia*), the Oak Eggar Moth (*Lasiocampa quercus*), a fine coffee-cloured species; and the Green Hairstreak (*Thecla rubi*), abundant amongst Bilberry on the Eastern Moorlands, but which, according to Spuler, does not feed on this plant on the Continent.* These species common to both ericetal and other insect communities are of great importance, as they afford a clue to the way in which non-moorland insects may become purely moorland insects.

Regarding this insect association as a whole, all the chief divisions of the order Lepidoptera, with one exception, are represented:—Butterflies, Silk Moths (*Bombyces*), the Night Moths (*Noctuæ*), the Loopers (*Geometræ*), the *Pyralidæ*, the *Tortrices*, and *Tineæ*. The exception is that of the Hawk Moths (*Sphingidæ*); these glorious forms have no moorland representatives, the reason being unknown. In Europe the species are almost equally distributed amongst the different groups, except in the Bombyces and Butterflies; there being about six of the former and five of the latter. To the paucity of moorland butterflies we have already alluded. On wet mosses, such as May Moss and Yarlsey Moss the Large Heath (*Cœnonmypha davus*) is not uncommon,

* "Die Schmetterlinge Europas."

where its caterpillars feed upon sedges ; whilst its relative, the Small Heath (*C. pamphilus*) is abundant everywhere on the uplands, the larvæ subsisting on grasses. In late May and early June, when the brilliant green carpets of young Bilberry stand out in vivid contrast to the dark brown Ling, the Green Hairstreak Butterfly will be seen flitting amongst it. Perhaps as you are crossing a bilberry-clad swidden a slight twitch of something green attracts your attention. Upon closer examination, the something green proves to be a Hairstreak at rest ; the green underside of its wings renders it almost invisible amongst the leaves.

Another fact brought out by this comparison of ericetal insect groups is that the abundance of a plant is no guarantee for an abundance of dependent Lepidoptera. Bracken is a most abundant fern, and yet supports three moths only, two of which occur in North-Eastern Yorkshire ; the Wood Swift (*Hepialus velleda*) feeding upon its roots, and a brown Geometer (*Panagra petraria*) feeding on its fronds. Compare his figure with the fifty species living on Ling or on Bilberry, clearly demonstrating that some other factor than abundance must be a cause in determining what species shall, and what shall not live upon plants. Still abundance must in many cases exert some effect ; for plants that are limited in size and of very restricted social habit cannot possibly support a great number of insects. The chemical nature of the Bracken may be a factor in keeping away insects ; but how the chemical composition of plants may affect them we are entirely ignorant.

A few moorland moths possess a somewhat similar type of colouration on the forewings, a mottled reddish hue. This feature is exemplified in the Little Yellow Underwing (*Anarta myrtilli*), the Heath Rustic (*Agrotis agathina*), the True Lover's Knot Moth (*Agrotis strigula*), and some micro-Lepidoptera, *Tortrix politana* for instance. This style of colour probably assimilates them to the ensemble of vegetable colours when they are at rest amongst the Ling. That

it is an adaptation to the colour of the flowers of the Heather is negatived by the fact that most of these moths appear before the Heather is in bloom, though the Heath Rustic and the Little Yellow Underwing are on the wing in August. The latter, however, may be seen from April to September on the moors where it is one of the most characteristic insects. On swiddens, a small moth (*Phycis fusca*) has sooty black wings ; and a normally green grasshopper also becomes quite black in similar haunts. This hue must have been acquired since mankind took to burning the moors. Together with the changes to melanism observed within recent years in other species of Lepidoptera, the change in *Phycis fusca* lends support to the idea that insect species evolve with greater rapidity than has been supposed.

The moorland Lepidoptera of North-Eastern Yorkshire appear to be distributed pretty evenly over the district. On the other hand two species, so far as present investigations go, are decidedly restricted in their range. *Noctua castanea*, a moth of common occurrence on most moors throughout Britain, has only been found near Scarborough. The Grass Wave (*Aspilates strigillaria*) occurs at Danby and Cloughton Newlands, and seems to be confined to those localities. But so large an area of the Eastern Moorlands remains to be explored entomologically that no data really exist on which to found any conclusions regarding their local range.

Having examined some of the general characteristics of the ericetal Lepidoptera, we must next consider its subdivisions in more detail. No species of the Myrica association has been recorded from North-Eastern Yorkshire, and though one or two probably occur where Gale is abundant, the majority of the species are of very local occurrence in Britain.

Of the Cotton Grass association, Haworth's Moth (*Celæna Haworthii*) is the most numerous, and the only recorded species from the Eastern Moorlands. Possessing brownish

forewings with white spots and lines, this dull-looking but nevertheless interesting insect lives as a caterpillar in the stem-bases of the Cotton Grass, and appears on the wing in August and September ; though I once came across a specimen on the bogs near Loose Howe as late as November. In its distribution the moth is decidedly northern. In this country it becomes more local as we go southwards, and is quite absent from the south-west of England. On the Continent it lives on moors from Lapland to the Urals, in Northern Germany, and in Northern France. Like the plant upon which it feeds, Haworth's Moth is of northern origin ; but it does not range so far south as the Cotton Sedges, nor is it found with them in Asia or North America. The fact of the moths becoming rarer southwards also shows that it is a species which originated in North Europe, whence it has gradually dispersed southwards.

The other Eriophorum-feeding Lepidoptera are small species whose larvæ live in the seed-heads, and whose distribution is essentially restricted to North and Central Europe.

Coming next to the typical moorland Lepidoptera, those subsisting on Heather and Heaths, and on Bilberry and its allies, it may be observed that both groups are practically equal in the number of species they support. Upon contrasting the way in which the families of the order are divided between the two groups, we obtain the following figures :—

	Callunal Association.		Vaccinial Association.
Bombyces	3		1
Noctuæ	9		8
Geometræ	10		14
Pyralides	5		1
Tortrices	6		16
Tiniæ	11		9
Psychids	4	Butterflies	3
	48		52

From this comparison we see that the Callunal group exceeds the Vaccinial in the families *Pyralidæ* and *Psychidæ* ; but the most noteworthy difference is in the number of *Tortrices*, there being ten more species on Bilberry and Cowberry than on Ling and Heath. The reason for this probably lies in the character of the plants and the habits of the Tortricid larvæ. The great majority of these pretty bell-shaped moths live as caterpillars between spun or rolled leaves, and this habit is more readily facilitated on Bilberry with its broad oval leaves than amongst the minute Heather leaves. The Vaccinial group also possesses species which could not live on Heather, viz., the leaf-miners (*Nepticula vitisella*). This habit is also clearly determined by the larger leaf area of Vaccinium. Such facts become significant when it is remembered that they illustrate beyond question that the nature of plants must to some extent determine the habits of the insects which feed upon them.

With regard to their geographical distribution, the two chief groups of moorland Lepidoptera possess quite distinct characteristics of the utmost importance. The great majority of the species of both associations occur in west central Europe, which must be regarded as their headquarters. But when we turn to the south of Europe we find there that the Vaccinial Lepidoptera are almost entirely wanting ; the few species that do occur being of almost universal range. On the other hand, the Callunal species number nearly thirty in south Europe, though twelve of these pass into the far north and belong to widely-ranging forms. In north Europe, although the Callunal insects are not absent, they are less numerous than in more southern countries, and far less numerous than the Vaccinial association which has about forty species in the same region. Out of the fifty species which constitute the Callunal group only nineteen are to be met with in north Europe, and some of these avoid the extreme north. It thus becomes clear that, while overlapping in central Europe, the two groups

are concentrated in a distinct manner ; the Callunal group in south and south-west Europe, the Vaccinial group in northern Europe.

Further characteristics are also possessed by these insects. A greater number of Vaccinial moths live in west Siberia, north Asia and North America. Only twelve species of Callunal moths pass into northern Asia as compared with eighteen Vaccinial, and some of the twelve do not always live upon moorland plants. In North America there are only five Callunal moths and ten Vaccinial. Again, far more of the latter group are mountain species in central Europe, and some of the species that do exist in south Europe only occur there on high mountains, in agreement with the distribution of their food-plants.

These general considerations regarding the distribution of the moorland Lepidoptera have been obtained by a tabulation of the range of the species ; and though it is impossible to give here in detail the mass of ascertained facts from which they have been derived, we must nevertheless illustrate them as far as possible by examples drawn from species that dwell upon the Eastern Moorlands (see Appendix).

Widely-distributed species of the Callunal group are the Emperor and Oak Eggar Moths, the former being found throughout the whole of Europe and far into Asia. The latter is also met with in all Europe, except the extreme north, and occurs through Asia Minor into Armenia and Siberia. Undoubtedly the wide range of these handsome insects is partly attributable to their ability to subsist upon other plants than Heather when they are caterpillars. The Moor Silver-Y Moth has also an extensive range, and moreover is one of the few Callunal species that has its headquarters in northern Europe, south of which it is found on high mountains as far as the Pyrenees and Urals. It even occurs in Greenland and northern Asia.

The western distribution of many Callunal moths is well

displayed by the pretty True Lover's Knot (*Agrotis strigula*). It lives on heaths throughout the British Islands, and on the Continent extends from Finland through central Europe to northern Italy and the Moldau. It is one of those insects whose distribution southwards has been hindered by the Pyrenees, south and west of which it is not

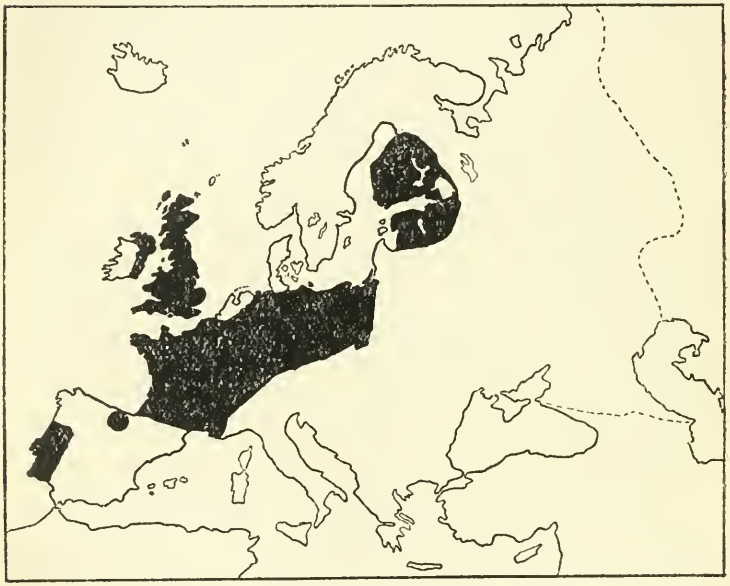


Fig. 67.—Map showing Distribution of Heath Rustic Moth (*Agrotis agathina*.)

known. A somewhat rarer moth, the Heath Rustic (*Agrotis agathina*), (Fig. 67), has a decidedly western range, but has been enabled to spread round the western end of the Pyrenees into northern Spain and Portugal.

Of species illustrating the more southern range of the Callunal association we may take, among others, the Grass Wave (*Aspilates strigillaria*), an insect previously referred to

as having a somewhat restricted distribution on the Eastern Moorlands (see plate). A whitish moth, with greyish lines across the wings, this species occurs in south and central Europe, southern Russia, Roumania, and thence eastwards to west and central Asia. That abundant and beautiful moorland moth, the Little Yellow Underwing (*Anarta myrtilli*), (Fig. 68), strikingly exemplifies the southern tendency

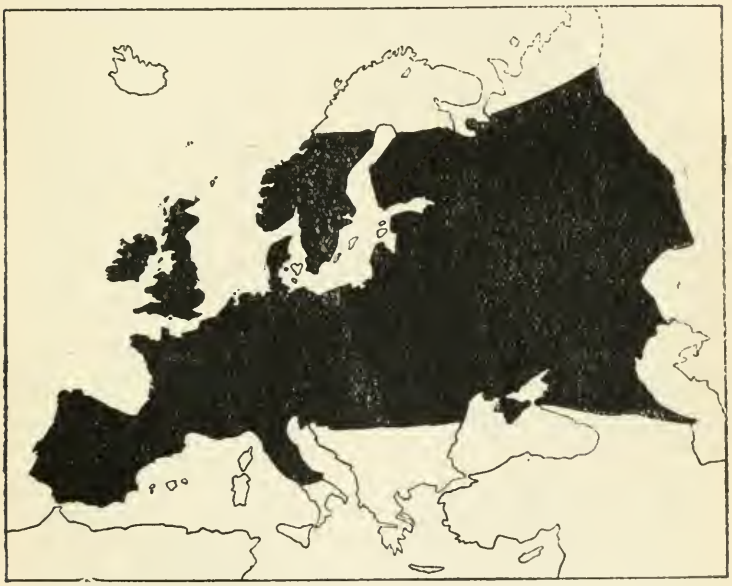


Fig. 68.—Map showing Distribution of the Little Yellow Underwing Moth (*Anarta myrtilli*).

of the Callunal group. It belongs to a genus—Anarta—confined essentially to Vaccinium in high latitudes, though one or two of the species occurs sporadically on mountains in the south of Europe. In the species in question, the larvæ feed—despite the specific name—on Heather and Heath ; and on looking at its distribution what do we find ?

Not only that it is absent from non-polar Europe, in this respect differing from all its congeners; but also, unlike them, it ranges far south into Andalusia, the south of France, and central Italy. And there are many other species of the Callunal group of Lepidoptera which possess a similar southward distribution.

Turning next to the Vaccinial group, the general similarity of the distribution of the different species renders a long series of illustrations unnecessary. The best instance is afforded by the Bilberry Moth (*Cloantha solidaginis*). Its distribution is very extensive, as will be seen from the map in Fig. 69. From Lapland across northern Europe to the Urals, in the Altai Mountains, in Amurland, in North America and in central Europe, particularly on hills and mountains, this species may be met with. It is one of those moorland moths which are also mountain moths, just in the same way that its food-plant, the Bilberry, grows upon low-lying moors and high peaks. In fact the range of this insect very nearly coincides with that of its food-plant.

Another widely-distributed species is the Moor Carpet (*Larentia cæsiata*) which has a range very similar to that of the preceding, and which occurs on mountains in central Europe where it is joined by two allies also living upon Bilberry. Without multiplying instances, it may be stated that the following Bilberry species from North-Eastern Yorkshire exhibit a northern and central European distribution:—*Hadena glauca*, *Cidaria populata*, *Hypsipetes sordidata*, *Acidalia fumata* and various *Tortrices*.

II

Hitherto we have only dealt with these interesting insects from a statical point of view, and it now remains for us to indicate in what way they have arisen. For many reasons any perfectly definite answer to this problem is almost

impossible. Lost in the vista of past centuries, their history has been so much affected by the Ice Age, that any conclusions derived from their distribution can only be considered as tentative. Nevertheless we propose to meet the problem in two ways :—first, by enquiring what their distribution signifies apart from geological considerations ; and second, by seeing what their relationship has been to the Ice Age.

And at the outset let us enquire into the process by which an insect may become a moorland species, for this will enable us to comprehend how such forms have originated in the past. A clue to the process we find in those insects which feed upon both moorland and other plants. Of these we have the Emperor and Oak Eggar Moths living upon Ling, Bramble, Hawthorn, etc., the Green Hairstreak Butterfly, and the July Highflyer (*Hypsipetes sordidata*). The latter has its Bilberry form slightly differentiated from the type living in woods and lanes. The moorland forms of the three first-named are evidently on their way to become distinct species, which will perhaps differ considerably from their allies restricted to other parts. We might even infer that those Lepidoptera confined to moorlands are older than those other ericetal species not so restricted, since with the lapse of a longer period they have become completely differentiated from their allies.

But we may carry the origin of moorland moths back to an earlier stage, a stage to be found in the visits paid by various non-moorland Lepidoptera to Heather bloom ; for it is quite conceivable that many of these visitors will lay their eggs upon moorland plants. Among the non-ericetal species known to visit the moors in August are the following—the Painted Lady (*Vanessa cardui*), *Lithosia complana, Agrotis tritici, Noctua glareosa, Noctua dahlii, Plusia festucæ, Stilbia anomala*, etc.* and I have found the White Butterflies, the Tortoiseshell, the Yellow Underwing, and the

* Knaggs, "Lepidopterists' Guide."

Angle Shades Moth upon the moors. Though far from their usual haunts, the fact of these species so occurring is not without import, for here the deposition of eggs upon the wrong food-plant may lead to the evolution of ericetal Lepidoptera.

The deposition of eggs upon the wrong food-plant must take place in nature, for we know that the instinct of oviposition is not unerring, moths of various kinds being in the habit of laying eggs in the pill-boxes, cages and glass jars used by collectors and breeders of these insects. Hence if any moth deposits its eggs upon Heather or Bilberry, on hatching, they will either perish, or under pressure of necessity feed upon the uncongenial food; and collectors are well aware that caterpillars may often be successfully reared on foods that they never touch under natural conditions. In most cases the mislaid eggs will perish; but, when the above facts are remembered, it cannot be denied that in the past such changes of food-plant must have taken place, and led to the formation of distinct races ultimately verging into species.

From this point of view the moorland moths, which feed upon other as well as moorland plants, assume a new aspect. On *a priori* grounds we might have concluded that some of the ericetal Lepidoptera have passed from plants either directly or indirectly associated with moors; and on compiling a list of the plants on which certain moorland moths can live, we find that most of them are associated with Heather, Heath, Bilberry, etc. Amongst such plants are the following :—Grasses (*Festuca, Aira*, etc.), *Rumex, Myosotis, Scabiosa*; Birch, *Lotus, Salix, Genista, Ulex, Cytisus*; Hawthorn, *Rubus, Polygala*; Oak, *Menyanthes, Pinus, Populus*; Holly, etc.

Caterpillars living upon trees with an undergrowth of ericetal plants might begin to feed upon the latter. Birch, Oak and Pine, as we have seen, often possess such an undergrowth, and it is to be noted that several moorland moths will also live upon these trees. That this transition has

actually taken place of course cannot be shown ; but if we turn back to the account of the Red Grouse we shall there find that this bird has been derived from a species—the Ripa—which frequents Birch woods with a moory undergrowth, and what has taken place with the bird may well have happened with the insects. As a matter of fact there is no such thing as absolute fixity of food for every kind of caterpillar. The experience of every entomologist proves this. In nature the food-plant must change with changing conditions, or if it profits a species in the struggle for existence. Where we have woods of Oak or Birch being replaced by moorland, the insects of the trees either leave the locality or perish, or some of them take to the new vegetation. Several moths are known in the course of their larval development to feed upon the leaves of trees at one period, and then upon low plants at another period. Certain sections of the species may take to living upon one or the other exclusively, and thus give rise to new forms.

Here, then, we have two methods by which moorland moths have arisen, viz. by the laying of eggs upon moorland plants visited by imagos either accidentally or for food ; and by the passage of larvæ from plants not already moorland (so far as our definition of moorland Lepidoptera is concerned) to Heather and Bilberry, caused by a change of food in the larval stage. In the first case the perfect insects initiate the transition ; in the second case the larvæ initiate the transition.

Further, when moths had become moorland and non-moorland, the conditions of life would tend to separate them more widely from one another. Another complication ensues when a moth subsisting on Ling might come to live on Bilberry, and *vice versa* ; a fact on which we have previously commented. Thus the moorland moths may have originated other moorland moths amongst themselves ; but to this point I have not yet been able to pay sufficient attention, though it would repay investigation.

There is still another way in which some moorland Lepidoptera may have arisen, and that only in former ages. They may have developed *pari passu* with the plants, and as these spread from their centres of origin, the insects spread with them ; and in this hypothesis we probably find a clue to the general aspects of their geographical distribution. We saw that there was a well-marked tendency for the Callunal Lepidoptera to range into the south and south-west of Europe, and to avoid the extreme north of the Continent. Now this range appears to have some connection with the southern or south-western origin of the Heather and the Heaths, which we discussed in Chapter VIII. For as these plants spread from that part of the Continent north and north-eastwards, moorland moths would naturally arise first in the former region and move with the plants. Although Heather is found throughout Europe, most of the Callunal Lepidoptera do not range so far north as it does, and this means one of two things :—either the insects have not yet had time to range so far as the plant, or they are not so easily adjustable to the cold climates of the north because of their more southern origin. We think the latter explanation to be the true one. Those moths with the range in question may have originated with the plants, and spread with them from south-west or southern Europe into the central and northern areas. On the other hand there can be no doubt that some must have originated in central Europe, and pushed northwards or southwards in their dispersal. On the Continent there are several moorland species peculiar to that region, and they have probably arisen there. Such is *Agrotis molothina*, unknown in Britain but found in France, Germany and Austria. The Moorland Silver-Y illustrates those Callunal moths which have arisen in the north, a genesis that has been of extremely rare occurrence amongst them.

The history of the species of Callunal Lepidoptera receives little testimony when we consider the distribution

of the genera ; for apart from the difficulty that these are somewhat differently defined by authorities, there is the further difficulty that many of the species belong to genera widely-spread over the northern hemisphere, and whose centres of origin are not readily traceable. Of the twenty-nine genera of Callunal Lepidoptera (according to Meyrick's classification), ten attain a maximum development in Europe and south Europe, viz., *Eupethecia, Bupalus, Lasiocampa, Pleurota,* etc. ; nine are generally abundant in the northern hemisphere (*Agrotis* for instance) ; eight are world-wide (*Plusia*) ; one is North American ; and one is Asiatic.* These data show that though many species have arisen from European genera, others have arisen, in Europe of course, from genera whose age is so great that their range has become very extensive. Some moths must undoubtedly have become associated with Heather when it was advancing from south-west Europe ; others would become associated when this plant reached the west central parts of the Continent, and thence spread southwards and northwards, whilst a minority would arise when the Heather reached the north.

The Emperor Moth seems to be a species of Asiatic origin that has long been in Europe and that has taken to a moorland life in comparatively recent times, since those Emperors met with on moors are not in any way distinct from those found in lanes and other non-moorland localities. In Europe there is another species (*Saturnia pavonia-major*), common in the south and passing into western Asia ; whilst *Saturnia spini,* a species very like the Emperor, lives in south-eastern Europe, western and central Asia. Our own species also penetrates into Central and Western Asia, in which Continent numerous other species of the genus are to be met with, and where it attains its maximum development. One species is peculiar to Western America. Such

* Handbook British Lepidoptera.

a distribution points to a probable diffusion of Emperor Moths from Asia by way of south-eastern Europe. Upon the evolution of heaths and moors the native species at once took to them, so that in some districts Emperor Moths and moors form an almost indissoluble association of ideas. The eye-like markings on the wings of this beautiful insect have long been a puzzle to evolutionists; but may it not be possible that the "eyes" were acquired in adaptation, not to its present environment, but to an ancestral environment? It is too frequently assumed that insect colours are only adapted to their present surroundings; but this is not obvious in the case of the Emperor Moth which may in its "eyes" still possess an adaptation to its Asiatic home, but which may be neither injurious nor of any apparent utility in its moorland haunts. It has been stated that this moth is protectively coloured when at rest upon the Heather. Apart from the fact that the insect is not found on moors over a wide area of its range where its colours on this theory would be of little use, the alleged resemblance is not true; for having noticed innumerable Emperor Moths at rest, I fail to see wherein the protection lies, for the insect is very conspicuous.

Leaving the Callunal Lepidoptera and turning to the Vaccinial, we shall find that the northern origin of these is much clearer than the origin of the southern group. The fact that all or nearly all the species are inhabitants of northern Europe, and do not occur in the south (despite the presence of the Bilberry and Cowberry), shows definitely their northern origin. If they had been insects of southern origin we should have expected them to be more numerous upon their food-plants in that area. Again the Vaccinial Lepidoptera have twelve species common to the American and European Continents, a distribution corresponding more or less to that of *Vaccinium*. From these facts we may conclude that as the Vacciniales arose in the manner previously described (Chapter VIII.), the insects originated

with them in the north, and gradually dispersed southwards with the advent of the cooler Pleistocene climates. Only a few species appear to have been evolved in central Europe; *Nepticula myrtillela*, a small moth which mines Bilberry leaves in the larval stage probably being one.

The genera of Vaccinial Lepidoptera (omitting those which also possess Callunal species) are generally distributed in north temperate regions; none appears to be peculiar to Europe, and this accords with the theory of their northern distribution. Of course, as in the case of the Heather moths, it can scarcely be doubted that some forms would arise after the Bilberry and its allies spread into central Europe, and these may have travelled northwards, but why they should have almost universally neglected to pass southwards is inexplicable on the theory of their mid-European evolution. When the two sets of ericetal plants commingled, the insects would become associated and pass from one plant to another as before indicated.

Such then appears to be the origin of the moorland Lepidoptera considered solely in relation to their geographical distribution and to the history of their food-plants. In dealing with them we have so far refrained from regarding them from a geological standpoint; but now the question arises as to their geological age and the influence of the Glacial Period upon their distribution. With respect to their age we possess no direct evidence to prove when these insects originated or when they first entered Britain. Of course they cannot be older than the ericetal plants, so that if they evolved contemporaneously with these, they date back probably to the late Pliocene or even earlier; and if the moorland plants were distributed then as now, the moths must have had a somewhat similar distribution. The on-coming of the Ice Age, however, would affect them profoundly, for wherever the glaciers existed animal life would be more or less impossible; and as most of northern Europe was thus covered, the pre-glacial faunas must have been

almost exterminated by the advent of the ice sheets. Only on oases left free at the period of maximum glaciation could any survival possibly take place, and it remains for us to see what occurred with the animal life of the moors at this momentous stage in their history.

The on-coming of the Glacial Period would in all probability lead to an influx of northern and Arctic species into the district, corresponding to an efflux of temperate and southern species. This efflux would act in two ways ; some species would move southwards, and others, more stationary in their habits and less adaptable, would die out. Now since the Callunal insects are more southern and temperate in their habits than the Vaccinial, it seems safe to infer that the former species became non-existent on the moors, and the latter, better adapted to cold climates, increased in numbers. With the epoch of maximum glaciation at hand, a refuge would still be available for many species on the driftless area, and having formerly given reasons for thinking that several plants survived the Ice Age within the limits of the ice-sheets, we shall find that there are equally cogent reasons for concluding that numerous insects living upon these plants, likewise passed through the age of cold on the driftless area. If any existing moorland or other species of British insects live in Greenland or other Arctic lands, then they in all likelihood lived throughout the Glacial Period in North-Eastern Yorkshire. Remembering that the ice-free area not only includes the open moors but also the more sheltered southern dales, let us note the evidence on which glacial survival may be established.

The following British insects live at the present time in Greenland ; the three marked with an asterisk being moorland species :—

Name.	Authority.
Lepidoptera.	
*Plusia interrogationis** ..	.. Rink
Eupethecia nanata var. *gelidata**	.. Spuler

Cheimatobia brumata	Rink
Hadena occulta var. *implicata* ..	Spuler
COLEOPTERA.	
*Bradycellus cognatus**	Fowler
Otiorrhynchus maurus	do.
Creophilus maxillosus	do.
Patrobus septentrionalis	Calwer
Quedius fuligidus	Fowler
HEMIPTERA.	
Orthezia cataphracta	Scharff

These are all that I have been able to find; doubtless others have been recorded; but the list shows it is exceedingly probable that some insects did manage to survive the Ice Age, and on looking at the Greenland and Arctic faunas generally there are further facts in support of the theory.

The cases of *Plusia interrogationis* and *Eupthecia nanata* are extremely instructive, for if such apparently delicate insects can become adapted to the icy conditions of Greenland, there seems no reason why other moorland moths should not also have become adapted to the icy climates of Pleistocene times. Singularly enough the two moths belong to the Callunal association, one of them being of northern origin.

The extraordinary adaptability of insects is well brought out by this enquiry. Apart from the species just enumerated, the Green Hairstreak Butterfly not only exists throughout Europe but also occurs in sub-tropical north Africa and in sub-Arctic Asia! This affords further support to the possibility of glacial survivals; and further verification is forthcoming when we consider the insect life of lands still nearer the Pole. "The officers of the British North Pole expedition, under the command of Sir George Nares, brought home a surprisingly rich insect fauna from Grinnell Land, lying between the seventy-eighth and eighty-third parallel of latitude, comprising no less than forty-five species of true insects and sixteen arachnids; the former

distributed as follows :—Hymenoptera, five species, including two humble bees ; Coleoptera, one ; Lepidoptera, thirteen ; Diptera, fifteen ; Hemiptera, one ; Mallophaga, seven ; and Collembola, three. Among the Lepidoptera are a number of forms belonging to genera common in the temperate zones such as *Colias*, *Argynnis*, *Lycæna*, etc., which appear the more remarkable seeing that the species of this order are more limited in Greenland (with an insect fauna numbering eighty species), and that no forms are met with either in Iceland or Spitzbergen, although upwards of three hundred species of insects are represented in the former."*

Taking all these facts into consideration, the adaptability of insects to extremes of climate, the faunas of the Arctic regions, and the isolated occurrence of species in connection with the unglaciated area (*ante*, p. 274), as well as the peculiar distribution of many insects in Europe—which appears inexplicable on the hypothesis of their having retreated southwards, and then advanced northwards again after the disappearance of the ice-sheets—we may conclude that the effects of the Ice Age on the moorland insects have not been so destructive as we might at first suppose ; and that wherever ice-free oases existed, invertebrates varying in numbers according to the areas of the different regions lived upon them throughout the Glacial Period. I believe that a careful investigation of unglaciated tracts of country in relation to the habits and distribution of insects will elucidate many problems of their present range. So far as the ericetal Lepidoptera are concerned, the Ice Age may not have caused great changes in their distribution. Some lived on unglaciated regions, and spread therefrom after the ice-sheets had waned ; northern forms doubtless spread southwards and ultimately died out in many southern localities, though a few managed to escape on to high mountains ; whilst the southern species remaining stationary in south Europe dispersed to their northern haunts after its close.

* Heilprin's 'Geographical Distribution of Animals," p. 280.

It is a question whether some species may not have arisen in post-glacial times, as we saw was the case with the Red Grouse. Local races of various Lepidoptera are known to occur in different parts of Europe and Great Britain. Thus we have in this country a dark form of *C. solidaginis* occurring as a variety at Cannock Chase, whilst it is widely diffused in various parts of Europe. Are we to suppose that this form and countless other local forms have existed since pre-glacial times, and participated in the great events of the Glacial Period ? Is it not much simpler to suppose they have been evolved in their present haunts since the Ice Age ? When we reflect on the rapid changes to melanism that have taken place with numerous moths within the last century, it seems a certain conclusion that insect species are modified with greater rapidity than has hitherto been thought possible. Entomologists have taken it for granted that species have existed unchanged for thousands of years, despite the fact that no evidence of this is forthcoming, for scientific observations of a continuous character have not been made for more than a few centuries. If our supposition be true, then we may explain a great number of peculiar distributions by assuming that the species concerned have arisen in post-glacial times.

After the Ice Age, those moorland species which had become extinct in North-Eastern Yorkshire would return either from the south of England or by land across the North Sea from the Continent, and their competition has unquestionably driven out most of the Arctic species which formerly lived upon the moors. Whatever botanical changes may have transpired in post-glacial times must have affected the fauna of the moors, though perhaps in a slight degree. It must always be borne in mind, too, that the changes which must have taken place with ericetal insects during the varying conditions of Pleistocene times, must have modified the aspects of their pre-glacial distribution, though how much we cannot say. And this

disturbing cause must always be recognised when attempting to deduce general conclusions regarding the origin of any group of British animals.

Our investigations into the origin of the moorland moths have carried us far from the peaty uplands of Black-a-more to the sunny shores of the Mediterranean, to the great chains of the Alps and Pyrenees, to Greenland, and to Siberia. These fragile insects which fly out of the Heather by the

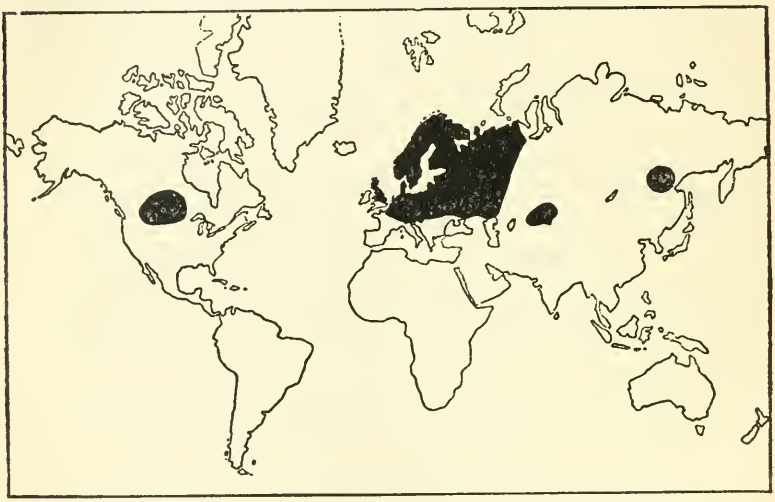


FIG. 69.—MAP SHOWING DISTRIBUTION OF BILBERRY MOTH, (*Cloantha solidaginis*).

roadsides on our familiar Yorkshire hills are the bearers of secrets to which those of state seem trifling in comparison. And as a last illustration of what they can tell us of the past we may refer to the evidence they furnish as to a former land connection between North America and north Europe. Nearly twenty species of these moorland moths including the Heath Pug, the Moor Carpet Moth, tne Bilberry Moth, the little black *Phycis fusca*, so abundant on swiddens, live in North America ; and it seems impossible

to imagine that they could have passed from one continent to the other unless direct land connections were available, probably in pre-glacial times.

With the Lepidoptera our account of the fauna must close, imperfect as the outline of this extensive subject has been. We cannot regard our knowledge of the fauna of the moors as anything like complete until further detailed work has been made upon the spiders, crustaceans, centipedes, and other forms of invertebrate life; and it may be years before we can treat of their origin in the same way that we have dealt with the origin of the birds and moths. From what has been said, however, we have learnt that the moorland animals have had a very complex history extending many ages into the past, and of which we can frame but inadequate ideas. For some, an imperfect picture of their evolution can be formed; for many others, even an imperfect picture is an impossibility, since all or nearly all records of their history have passed away for ever.

CHAPTER XVII

CONCLUSION.

WE have now reached the end of our investigation into the origin and natural history of the Eastern Moorlands. To the questions propounded at the outset we have received definite answers ; and it will be well before bringing this work to a close to review the results we have obtained, and to sum up as briefly as the complexity of the subject will allow, the causes which have led to the evolution of the moorlands of North-Eastern Yorkshire.

Enquiring into the present botanical aspects of the moors, we first examined their plant associations, their relative abundance, and their distribution over the district. We found that the pure Heather moor, both of the fat and thin varieties is by far the most dominant of all the ericetal plant communities, though in certain well-defined areas it is replaced by associations in which Ling occupies but a subordinate position and even becomes totally absent. Of these the Cotton Sedge and Sphagnum Bog- -Eriophoretum—prevails upon the high central watershed and in many of the slacks, though existing sporadically on a small scale on most moors. Where, towards their boundary, the moors shelve away in gentle slopes, grasses of various species and Furze constitute a prominent feature of the vegetation, and we observed that such heathy pastures on some parts of the Tabular Hills become grassy commons with little or no Heather in their composition. On steep slopes, Bracken and Bilberry were seen to be the characteristic plants, and in many instances to flourish under Birch and Oak trees in wooded gills. Junceta were found to be of very general occurrence principally in

shallow slacks and occasionally on the Mosses ; whilst bogs, characterised by the presence of Sweet Gale appear to be restricted to the south-eastern portion of the moorland country.

These differences in the plant life we next found to correspond more or less closely to variations in the nature of the soil, variations due to position in relation to slope and rainfall. The soil in its original form consisted of sand and coarse sandstone ; but the action of the plants has resulted in the formation of deposits of peat or raw-humus, the varying proportions of which largely influence the vegetation. On the pure Heather moor, the raw-humus, about a foot in depth, covers a peaty sand, at the base of which and resting upon the stony soil, runs a hard band of that remarkable substance called moor-pan. On reviewing the transitional stages to the Common we saw the peat become thinner and thinner until it disappears, the stony soil ultimately rising to the surface. Coincident with these changes we noted that the grass moors are much drier and that pan is absent from them.

On the other hand the Eriophoreta exist under conditions quite the reverse of these. Here the raw-humus forms vast beds of peat often thirty feet thick and very wet at all times of the year. To these edaphic conditions the moorland plants are specially adapted, and as showing how other species could not live upon the moors we instanced the remarkable fact that on swiddens non-ericetal plants never appear.

We briefly glanced at the climatic condition of the Eastern Moorlands, and found that owing to their elevation the rainfall averages about thirty-two inches per annum and is probably much more upon the watershed ; whilst it exceeds that of the lowlands by at least six inches per annum. These conditions of plant life agree in all particulars with those obtaining in other moorland districts ; and it can now be confidently asserted that the essential atmos-

pheric conditions for the development of Heather moorland, are a plentful supply of rain not falling below twenty-four inches per annum, as the researches of Graebner on the north German plain prove, and an open winter where long frosts are not frequent. Where the rainfall exceeds this minimum as it does in North-Eastern Yorkshire, we find the wetter types of ericetal vegetation ; and on the wettest parts of the uplands, the central watershed, these types dominate. The essential edaphic conditions are a poor sandy soil deficient in plant food, and above all a great thickness of raw-humus or peat, which is especially developed where the moisture conditions are excessive ; peat being practically absent from the drier grass moors. On such grass moors we noticed that the Heather is stunted in growth and less dominant ; but where the peat is very thick and very wet, the Heather, although not dwarfed, has to yield to plants more suitable to wetter localities—Cotton Sedge, Bog Moss, and Pink Bell Heath. The presence of pan is thus shown to be non-essential, its principal effect being that it prevents the roots of trees or non-moorland plants from reaching the true soil and so hinders their vigorous or abundant growth. Pan underlies a considerable area of the Eastern Moorlands, but is clearly absent even from many pure Heather moors ; though here the thickness of the raw-humus is so great and the Heather so vigorous that other species have very little opportunity of obtaining a foothold.

The peculiar vegetation of slopes was ascribable to different conditions from those of the true moors, viz., to an accumulation of down-wash, to shelter from the wind, to the general absence of thick peat, and to the position of the slope as regards the points of the compass as well as to its inclination.

Having thus ascertained the present botanical aspects of the moors, we then considered their origin and the changes they had undergone since the moorland plants first entered the district. We saw reasons for thinking that the Heather

and Heaths arose in south and south-west Europe in the Pliocene period, and that the Bilberry and its allies, the Cotton Sedges and other species, arose in northern lands (the exact centre being undeterminable) during the same geological age. The moors probably existed in late Pliocene times, and the researches of Mr. Clement Reid were quoted to show how the ericetal species ranged back not only to the Glacial Period but also to the late Pliocene.

Special attention was directed to the glaciation of the moorland country, and it was pointed out how the uplands were ice-free at that period, but that the ice-sheets surrounding them obstructed the drainage of the dales, and caused glacier-lakes to be formed in the valleys, the overflow channels of which lakes—the slacks—form such a striking feature of the northern and eastern moors, and which have been so ably elucidated by Professor Kendall. We also found that on parts of the moors, more especially in the north and east, their boundary coincided with the line of maximum glaciation, the superior soils of the drift-covered country being more amenable to reclamation than the driftless area.

Reasons were also advanced for thinking that the driftless area supported some kind of vegetation during the Ice Age —an oasis of life in a desert of ice—including not only genuine Arctic species but also most of the chief members of the present flora—Heather, Cotton Sedges, Crowberry, Mat Grass, etc. To the facts adduced in support of this contention may also be quoted another fact which still further strengthens the idea. In Siberia there occurs what is known as " fossil ice," which, owing to the rigour of the climate, has survived from the Glacial Period, and upon the surface of which peat with plants has accumulated!

With the disappearance of the glaciers and the amelioration of the climate, moors developed from the Arctic plant communities of the driftless area, stragglers of which alone remain, the Dwarf Cornel, the Bearberry, Linnæa, etc.

In post-glacial times many plants that became extinct in the district during the Ice Age again re-appeared on the scene—Bracken, Sweet Gale, and the two Heaths.

The data we obtained from our investigation of the present botanical aspects of the moors, enabled us to trace their development both in regard to their vegetation and their soils. Besides indicating the manner in which Heather moorland arose on the bare soil, we also described the history and origin of the peat mosses of the watershed and the glacial slacks, and showed how the former had largely replaced the site of pools or small lakes, and the latter had occupied the site of woods of Oak and Birch. The former wooded state of the moors is a problem to which we devoted much attention, and from the available evidence we came to the conclusion that, though the Bracken slopes, slacks, and gills, and some parts of the lower moors have undoubtedly been clothed with scrubs of Oak, Birch, and Rowan, yet the higher moors were never so clothed. In Chapter I. we inferred this from an examination of the course of the roads and other facts ; a conclusion which we were enabled to confirm in the chapter on the Mosses by finding that their great beds of peat are practically devoid of tree remains. The destruction of the timber in the slacks, though probably accelerated by man, we could not definitely ascribe to fluctuations of climate in post-glacial times, for though the peat beds of North-Eastern Yorkshire yield evidence of one Forestian stage, the disappearance of trees in these valleys seems to be due to their peculiar drainage conditions leading to the development of bogs upon their floors, which development takes place under most changes of climate except very dry ones. Before the coming of man the general aspect of the district was that of forest above which rose the moorlands. In the forest roamed the deer, the bear, the wild ox, and the wild boar ; whilst the moors were the home of the fox, the wolf, the grouse, the raven, and the eagle.

Conclusion

Although the boundary of the moors was partially accounted for by the glaciation of the district, their southern and western limits could not be thus explained. The solution to this problem we found in the character, deposition, and geological history of the moorland rocks, which have been the chief factors at work in causing the peculiar distribution of the Eastern Moorlands. First, we dealt with these strata according to their geological age and character, and noted the conditions under which they were deposited in the Jurassic period. The formation of the Bajocian estuarine grits and sandstones constitutes the earliest stage in the evolution of the moors. For the sands and muds out of which these strata have been formed and into which they are again being resolved, gave rise to the barren stony soils of the uplands, so indispensable in the development of Heather moorland. After their deposition these strata underwent many changes until after the Cretaceous period they were uplifted above the sea, and worn down to a plain of marine or sub-aerial denudation. We advanced reasons for thinking that the old hypothesis of Phillips, viz., that the sea has been responsible for the even-topped uplands, receives a partial verification in the presence of peculiar quartzite pebbles occurring on the moors near Glaisdale and Goathland ; but in whatever particular way the moorland plateau was formed, it underwent a further uplift in Miocene times, which produced a dome-shaped mass of high land. We may best picture to ourselves the geological structure of the moorland country if we take Botton Head as a centre. Eastwards, for fifteen miles, dips the anticline ; whilst north and south, the strata roll over to the Esk Valley and the Vale of Pickering.

These dips profoundly affected the erosion of the moorland rocks and led to their present distribution, the formation of the great dales, and the bold escarpments of the Tabular, Cleveland, and Hambleton Hills. The southern boundary of the moors was observed to coincide more or

less closely with the Tabular range, due to the fact that with them the Bajocian strata no longer appear at the surface, but are covered by the rich calcareous Corallian rocks which produce soils unsuited to moorland plants. The large area occupied by the Bajocian beds we found was owing to their harder character and to their having been less exposed to erosion than the softer overlying strata. With the aid of the geological structure we were enabled to trace the origin of many of the physical features of the moors, such as the Hole of Horcum, Freeborough Hill, the Howe at Castleton, the outliers of Moor Grit and Kellaways Rock, and the moorland scarps and boulders.

Lastly, the fauna of the moors claimed our attention. Somewhat scanty as this was found to be, it was shown that the animal life of the moors has not been without influence upon the vegetation ; and as instances of this influence it was pointed out how sheep cause grass to appear, how ants distribute seeds, and how the soil remains undisturbed by moles, worms, or grubs. The fauna must also have participated in the history of the flora ; and when examining the Lepidoptera we concluded that their distribution in two well-defined areas of Europe was to some extent indicative of their origin with their respective food plants, the Bilberry and its allies in the north, and the Heather and its allies in south and west Europe. The history of the Red Grouse was studied in detail not only because it is the characteristic bird of the moors, but also because it very clearly illustrates how a knowledge of the past botanical and geological changes the moors have undergone, elucidates the origin of their animal inhabitants. In truth the history of the Red Grouse has wider ramifications than we might suppose ; for grouse shooting has largely determined the movements of society in August—the " rush to the moors "—and is indirectly responsible for the general holidays of that month ; and since the Red Grouse probably owes its presence in Britain to the Ice Age, we see clearly that

but for that colossal episode particular movements of mankind would not have taken place.

The altitude of the moors is too low for any markedly northern types of animals to live upon them. With the exception of a few species the fauna forms part of that typical of England, viz., the Continental or Germanic type, and consequently it does not differ greatly from that of lowland heaths in other parts of the country. The high watershed between the great dales has not yet been explored by zoologists, and it is not unlikely that some rare species may be discovered which will further elucidate the zoological history of North-Eastern Yorkshire.

We have also surveyed many remarkable scenes—the intricate network of glacial valleys on Murk Mire Moor and behind Robin Hood's Bay ; the wide expanses of peat and bog on the watershed ; the great dales radiating from the tableland ; the impressive ranges of the Cleveland, Hambleton, and Tabular Hills with their singular outliers ; the breezy upland swards of Dalby Warren, intersected by deep heather-clad gorges ; and the precipitous cliffs and wonderful aspects of Newton Dale. We have also traced the equally remarkable changes which these scenes have undergone in past ages ; the estuarine conditions which led to the formation of the rocks ; the origin of the familiar moorland plants—Bracken, Heather, Bilberry, Sweet Gale ; the formation of peat and acid humus, and the indications they yield of the former wooded state of the uplands ; the natural architecture and sculpturing of the dales and hills ; the evidences of the Great Ice Age in the form of a system of glacier-lakes ; and the history of the moorland animals and their influence upon the plant life.

Thus in these pages we have endeavoured to show that the black and brown peat with its embedded boulders, the plants nodding over the lichened surfaces of the stones, the insects and birds concealed in the vegetation, and the storms of rain and wind which sweep over the moorland plateau,

form an impressive whole which cannot be fully understood unless all its elements are considered.

Before finally leaving the moors let us once more survey from some coign of vantage this land of Heather and peat with the accumulated knowledge which we now possess of its plant life, natural history, and origin. From no one point is it possible to survey the whole of Black-a-more; but from the moors to the east of Goathland we obtain perhaps the most comprehensive view of the region we have been studying. Taking our stand at Lilla Cross (Fig. 70) we find ourselves once more with the wide moorlands outspread on all sides. We feel the Heather and peat beneath our feet; we inhale the keen upland air; the calls of the Grouse and Curlew fall upon our ears—all indispensable elements of the scene before us. On every side dark heather-clad swells, crowned with ancient tumuli, rise and fall like waves of the sea. In the south towers the great escarpment of the Tabular Hills at Hackness, Langdale, Cross Cliff, and Saltersgate, extending eastwards to that bold spur on which the Roman legions erected their camps.

Eastwards lie the stony moors between Peak and the Symes Valley. Trenched by many a slack of glacial age and bordered beyond by the sea, these moors fall towards the rocky ravine of Jugger Howe Dale. Little of this imposing cañon can be made out from Lilla Cross; but former excursions enable us to picture the winding slack with its boulder-strewn tree-clad slopes, its floor carpeted with sweet-scented Gale, and its extraordinary tributary network of dry valleys near Robin Hood's Bay. The moors between our standpoint and Jugger Howe Dale are traversed by the headwaters of the Derwent; that remarkable river which no longer flows to the ocean along its original course but has been turned aside and remains a witness to the influence of the Great Ice Age.

Turning westwards we behold, as far as the eye can see, ridge after ridge radiating from the watershed, whilst Newton Dale, with its precipitous crags, lies in the immediate fore-

Photo by. FIG. 70.—LILLA CROSS. *[E. Wray.*

ground. Beyond the distant swell of Danby Beacon projects the conical summit of Roseberry Topping. Imagination carries us thence to the moorlands of North Cleveland, the Hambletons, and the western valleys of Raisdale and Ryedale.

Such, is the scene presented to us at Lilla Cross. We might have taken others from the watershed along which extend the Mosses; or from the Tabular Hills, whence rise the purple moors like a great wave to the horizon; or from Black Hambleton, whence we look eastwards along the bold range of nabs pushing northwards into Black-a-more; or even from Danby Beacon, whence we can behold the northern dales in all their beauty.

APPENDIX.

THE ERICETAL LEPIDOPTERA OF EUROPE.

WHEN investigating the origin of the moorland Lepidoptera, I prepared two tables giving a digest of all the principal facts regarding the two chief groups of species, those living upon *Calluna* and *Erica*, and those living on *Vaccinium*. Thinking that these tables may be of use to students of entomology, I have decided to publish them in this appendix, and they will serve not only for future reference but can also be used to test the conclusions reached in Chapter XVI.

Each table is divided into seven columns—the first column giving the name; the second, the distribution; the third, the time of the insect's appearance; the fourth, the period of the larval stage; the fifth, the chief food plant; the sixth other food plants; the final column being reserved for any noteworthyr emarks. I have also included in these tables Lepidoptera subsisting upon the Ericaceæ of South Europe, and Lepidoptera subsisting upon *Vaccinium uliginosum* and *oxycoccus*. My principal sources of information have been Spuler's " Schmetterlinge Europas " and Meyrick's " Handbook of British Lepidoptera."

Table I. CALLUNAL LEPIDOPTERA.

Name.	Distribution.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	Remarks.
Saturnia.						
**Pavonia* L.	Whole of Europe, except Sardinia and Corsica ? (Spul.); north and west Ireland, far into Palæarctic Asia,	April to June.	May to August.	Calluna.	Prunus, Vaccinium, Rose, Bramble, Spiræa ulmifolia, Sallow.	
Lasiocampa.						
**Quercus* L.	All Europe, except Polar. Through Asia Minor to Armenia, and in Siberia.	June to August.				
V. alpina Frey.	Alps.		Hibernates to May.	Calluna.	Blackthorn, Birch, Oak, Sallow, Sarothamnus.	
V. callunæ Palm.	Scotland and Sweden, as an aberration in south German Mountains.					
V. roboris Schrk.	South-west France and northern Portugal.					
V. spartii Hb.	South France, neighbouring parts of Italy and south Tyrol. Central Spain.					
V. sicula Stgr.	Sicily and Andalusia.					
Orgyia.						
Ericæ Germ.	Belgium, Holland, north Germany southwards to north Saxony and Denmark, in Esthonia and Livonia and in Russia southwards to Charkow, and south-easterly to Pesth and Bukowina.	July, August.	May to July.	Calluna and Erica tetralix	Myrica gale, Andromeda polifolia.	On moors.
V. intermedia Friv.	South-east Russia. In central Hungary, southwards to Mehadia.					

Acronycta.	Norfolk and Shropshire to Ross, north and west of Ireland.					
**Menyanthidis* View.	North and central Europe, except France. East Asia and central Asia.	May, June.	June to August.	Menyanthes trifoliata, Calluna.	Vaccinium oxycoccus, Myrica gale, Salix.	On moors. In south part of European range in mountains (Spul).
V. obsoleta Tutt.	Dark form only form in north.					
Acronycta. *Auricoma* F.	Kent to Hampshire; North and central Europe, and southwards to Portugal, central Italy, Croatia, and south Russia. Armenia and through Siberia to Amur.	May, June, July, August	June to October.	Calluna. In Portugal on Erica aragonensis.	Vaccinium myrtillus and vitis-idæa, Rubus caesius Rubus fruticosus Also on leafy trees	
V. brumosa Gn.	North America.				In Alps on Gentiana asclepiadea.	
V. pepli Hb.	Esthonia to Lapland.					
Agrotis. **Strigula* Thnb.	Ireland, Britain, Shetlands. Reaches an altitude of 2000 metres. From Finland and central Scandinavia through central Europe to north Italy and the Moldau. Pyrenees, Jutland.	June, July.	Autumn to Spring.	Calluna, E. herbacea and cinerea.		
V. suffusa Tutt.	Shetlands.					
Agrotis. *Molothina* Esp.	Livonia, central France, Rhinepfalz, neighbourhood of Dresden, lower Austria, Moravia, Hungary.	May and June.		Calluna vulgaris.		On wide moors, very rare and local (Spuler).

TABLE I.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	REMARKS.
**Castanea* Esp.	Esthonia, Livonia, and Denmark only form; also in southern Scandinavia, England, central and south Germany, Switzerland; but not occurring over wide areas.	July to mid-September.	October to May.	Calluna.	Vaccinium, Genista.	
V. neglecta Hb.	In west Europe to Portugal, in Italy and Austria-Hungary, Alsace and Würtemberg.					
**Agathina* Dup.	Britain, Orkneys, north and east Ireland, Portugal, Bilbao, France, Belgium, Tarmus, Alsace, Finland, Esthonia, Lausitz.	August.	September to June.	Calluna, Erica cinerea, arborea and multiflora.		
V. scoporiæ Müll.	South France, in north as ab.					
V. hebridicola Stgr.	Hebrides.					
ANARTA. **Myrtilli* L.	All Britain and Ireland. In non-polar north and central Europe, south France, Spain, north and central Italy.	May, June, July.	August and September.	Calluna, Erica carnea.	Said to live on Vaccinium.	Double-brooded.
V? and *ab. alpina* Rätz.	Central Switzerland, as aberration in Germany and Andalusia.					

PLUSIA. * *Interrogationis* L. *Var. transbaicalensis*	England, Scotland, Ireland. All north Europe and the high mountains of central Europe, to the south Ural, the south-east Carpathians and neighbouring mountains, northern Apennines, the Pyrenees, Greenland. Daurien and east Siberia.	June, July.	May, June.	Calluna.	Vaccinium uliginosum and myrtillus (Spuler).	On peaty moors (Spuler).
HYPENODES. *Taenialis* Hb.	England, Holland, south Sweden, Germany, lower Austria, Galicia, Pleskau, Caucasus, Armenia, Canary Islands.	June, July, August, September.	Early Summer and August.	Flowers of Calluna.	Flowers of Thyme	
NEMORIA. **Viridata* L.	Europe, except Polar area. Palæarctic Asia.	May to July.	August.	Calluna vulgaris.	Whitethorn.	
EUPETHECIA. *Callunæ* Spr.	England.	June to August.	September, October.	Calluna.	Eupatorum. Scabiosa succisa.	
Scopariata Rbr.	France, Corsica, Spain, Tuscany, Algeria, Island of Lessa in Dalmatia.	April and May.	September and October.	Erica arborea, and scoparia.		
* *Nanata* Hb. *V. pauxillaria* B. *V. gelidata* Möschl.	Central and north Europe, north Spain, Italy, Dalmatia, south France, central Italy, Castile, Shetlands, Labrador, Greenland.	May to July.	June and August.	Calluna, Erica cinerea and carnea.		

TABLE I.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plants.	Other Food Plants.	REMARKS.
PACHYCNEMIA. *Hippocastanaria* Hb.	Kent to Somerset and Sussex, central and south Europe except Sicily, Denmark and Algeria.	May and August.		Calluna, and in south on Erica arborescens.		Only in healthy localities (Spuler).
GNOPHOS. *tibiaria* Rbr.	France, especially south; Corsica and Istria.	September.	September to March.	Erica scoparia and arborea.		
HEMATURGA. * *Atomaria* L.	All Europe except Andalusia and Sicily, west Asia, Siberia to Amurland.	April to August.		Calluna.	Spartium, Centaurea, Lythrum, and other plants.	
V. orientaria Stgr.	South Tyrol, Istria, Greece, Asia Minor.					
V. iliaria Alph.	Western Thian-Schan Province.					
SELIDOSEMA. *Ericetaria* Vill.	Sussex to Dorset, Warwick, Cheshire, Arran, east and south Ireland, Austria-Hungary, west Germany, Bavaria, Switzerland, France, north and central Italy, Greece and west Asia.	July and August.	May and June.	Calluna.	Lotus corniculatus Genista.	
V. pyrenæaria Hb.	Pyrenees and Spain.					
V. syriacaria Stgr.	Syria.					
V. scandinavaria Stgr	South Scandinavia, Denmark, Gothland.					
V. oliveirata Mab.	Portugal.					
V. pallidaria Stgr.	Sicily, Dalmatia, central Italy and Amasia.					

SCODIONA. **Fagaria* Thnbg. (*belgaria*, Hb.).	Southern Scandinavia, England, Holland, Belgium, north-west Germany, south-east Russia, Armenia.	April, May.	Hibernates.	Calluna.	Globularia (near Vienna).	
Ab. psoricaria Ev.	Sarepta, Armenia, Turkomania.					
V. favillacearia Hb.	Austria-Hungary, Galicia.					
V. albidaria Stgr.	France, Belgium, England.					
PERCONIA. **Strigillaria* Hb.	England, Moray, Ross, north and west Ireland; in eastern, central and south Europe; south Russia, Roumania, west and central Asia.	May, June.	August to May.	Erica and Calluna.	Sarothamnus.	
Ab. griescaria Stgr.	Saxony, north Germany, Livonia.					
V. cretaria Ev.	South-east Russia.					
PACHYTHEILIA. *Villosella* O.	Hants. and Dorset. Spread throughout central Europe to south Sweden; and in north-south Europe, Asia Minor (Meyrick).	June, July.	July to May (two years).	Calluna.	Grass, etc.	
PHALACROPTERYX. *Graslinella* B.	Central Europe (except England and Switzerland), and southern north Europe, local.	April, May.	Two years.	Calluna.		
Præcellens Stgr.	Castile (Sierra de Guadarrama).			Erica arborescens (exclusively).		
Calberlæ Heyl.	Pyrenees and south Tyrol.	April.		Erica.		

TABLE I.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	REMARKS.
CRAMBUS. *Ericellus* Hb.	Cumberland, Perth to Orkneys. In central and north Europe.	July.				On moors. Larva unknown.
SELAGIA. *Argyrella* Schiff.	In central Europe to Livonia (except England), Italy and west Asia.	August.	September to July.	Calluna.		
SALEBRIA. *Palumbella* Schif.	Britain to Kirkcudbright, east Ireland; central and south Europe, north; and west-central Asia to north India, north Africa.	May to August.	September to May.	Erica.	Polygala.	
**Fusca* Haw.	Great Britain and Ireland, north and central Europe, Catalonia, north Italy, Japan, Asia Minor North America.	June and July.	July to September.	Erica and Calluna.	Salix.	
ACROBARIS. *Porphyrella* Dup.	South-west Europe, Italy and Dalmatia.	May to July.	February to March.	Erica scoparia.		
ACALLA. **Mixtana* Hb.	Great Britain (to Ross), central Europe, Scandinavia.	September to April.	June, July.	Calluna and Erica.		
TORTRIX. **Politana* Hw.	Britain to Caledonian Canal, east and west Ireland, all Europe except far north, North America.	June, July.	September.	Erica, Calluna.	Myrica, Centaurea, Ledum, Potentilla fragaria, Ranunculus acris Senecio jacobæa, Vaccinium.	

PAMPLUSIA. **Mercuriana* Hb.	Hereford to Shetlands, north Ireland, common. North and mountains of central Europe.	July.	September to June.	Calluna.	Dryas.	
ANCLYIS. *Unguicella* L.	Britain to Shetlands, north Ireland, north and central Europe, Spain, Italy Dalmatia, south-east Russia.	April to June. July to August.	June, July, September to Spring.	Calluna and Erica.		
Uncana Hb.	Britain to Sutherland, north Ireland, Italy, Russia, central and north Europe.	May to June.	July, August.	Calluna, Erica.	Birch.	
EPIBLEMA. *Fusculana* Z.	South and west France, Sardinia, Sicily, Andalusia.	April, May.				Flies round Erica (Spuler).
ARISTOTELIA. *Ericinella* Dup.	England to Westmoreland, central Europe, north-west Russia, south France.	July, August.	June, July,	Calluna.		
XENOLECHIA. **Æthiops* West.	Cheshire to Northumberland, Holland and Germany.	May, June.	June, July.	Erica cinerea.		
GELECHIA. **Ericetella* Hb.	Britain to Shetlands, Ireland, Europe, Asia Minor	May, June.	September to March	Calluna, Erica.	Rhododendron.	

TABLE I.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	REMARKS.
PLEUROTA. **Bicostella* Cl.	Britain to Sutherland, north Ireland, west-central and south-east Europe, north Africa, Mongolia.	June, July.	September to May.	Erica, Calluna.		
AMPHISBATIS. *Incongruella* Z.	England to Cumberland, central and south-west Europe.	April.	June.	Calluna.		
COLEOPHORA. *Juncicolella* Stt.	Britain to Caledonian Canal, Holland, Germany, Switzerland.	June, July.	September to April.	Calluna and Erica.		
Pyrrhuli-pennella Z.	England to Westmoreland, central Europe, north Asia Minor, south Europe, north-west Russia, south Norway.	July.	September to May.	Calluna and Erica.		
SCYTHRIS. *Variella* Stphs.	Hants. and Dorset, north and north-central Europe	June, July.	May.	Calluna.	Rumex acetosa.	Larvæ live in long silken galleries.
SCYTHRIS *Ericevorella* Rag	France		May.	Erica tetralix		

SCYTHRIS. *Insulella* Stgr.	Andalusia and Portugal.			Erica.		
HYPONOMEUTA. *Egregriellus* Dup.	Spain, south France, Piedmont, south Tyrol, Dalmatia.	May, June.	March.	Erica scoparia and arborea.		
GELECHIA. *Virgella* Thnbg.	North Europe, England, Germany, Alps, France, west and central Italy, north Asia Minor.	May, June.	April, May.	Calluna.		

* Indicates species recorded from the Eastern Moorlands.

Table II.—VACCINIAL LEPIDOPTERA.

Name.	Distribution.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	Remarks.
Colias. *Palæno* L. *V. europomene* Esp. *V. alpina* Spul.	Scandinavia and north Russia. Central Europe and Livonia, sporadically in the Black Forest. High Mountains of Europe, south-eastwards to Bukowina.	Middle of June to August.	May.	Vaccinium uliginosum.		A clouded yellow butterfly. On peat moors (Spuler). In very favourable years double brooded.
Callophrys. **Rubi* L.	Whole palæarctic region north Africa, Japan, Britain to Ross, Ireland.	April to July	June, July, Autumn.	Vaccinium myrtillus, in parts of Britain.	Ulex, Genista tinctoria, Clover, Cytisus, Spartium, Rubus, Veronica, Onobrychis sativa, Cornus sanguinea, (flowers), Sedum palustre, Birch.	Green Hairstreak. Double and sometimes treble-brooded (Spul.).
Lycaena. *Optilete* Kn. *V. cyparissus* Hb.	North and central Europe, northern Asia to the Amur. In High Mountains, Lapland and north Siberia.	June to August. July and August.	Autumn to June.	Vaccinium oxycoccus.		On peaty moors (Spul.). A blue butterfly.

EPICNAPTERA. *Ilicifolia* L. *V. japonica* Leech.	Stafford to York. Scandinavia and Finland, through central Europe to north Italy and to Bukowina. In Asia to Amurland. Japan.	April, May.	August.	Vaccinium myrtillus.	Salix.	
AGROTIS. *Hyperborea* Zett. *V. alpina* Hum. and Westw. *V carnica* Her.	North and central Scandinavia, from Finland to the Carpathians and the Silesian Mountains, and on the High Alps. Perthshire to the Shetlands, on mountains. Carnatian Alps and Scotland.	July and August.	August to May.	Vaccinium myrtillus.		Especially in firwoods under moss in places where V. myrtillus grows (Spuler).
AGROTIS. *Speciosa* Hb. *V. ægrota* Alph. *V. obscura* Frey. *V. arctica* Zett.	Scandinavia, Finland, and Russian Baltic Provinces, and rarely on the mountains of central Germany and the Alps; once in the Siebenbürgen. Mongolia. High Alps. In the far north, from the central Scandinavian and Finland mountains.	July.		Vaccinium myrtillus.		
MAMESTRA. **Glauca* Hb.	Norfolk and Worcestershire to the Orkneys, north and central Europe on mountains to the Alps and Wallachian mountains, south Russia and east Asia.	June.	July, August.	Vaccinium myrtillus and uliginosum.	Aconitum, Salix, Tussilago.	A form both ericetal and mountain.

TABLE II.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	REMARKS.
ORRHODIA. *Daubei* Dup.	South France.	September.		Vaccinium vitis-idæa (Spuler, p. 255).		
XYLINA. *Lambda.*	In north Scandinavia, Livonia, north Russia, occasionally in England, Amurland.	Autumn to Spring.		Vaccinium uliginosum.	Myrica gale.	
Ab. and *V. somniculosa* Hering.	North Germany (Berlin) as variety, north Russia and Schonen as aberration.		May and June.			
V. and *ab. zinckeni* Tr.	North-west Germany, Belgium, England, Aargau (Switzerland), Salzburg, in Schonen as variety, in Scandinavia and north Russia as aberration, as variety in North America.					

CALOCAMPA. **Solidaginis* Hb. *Ab. cinerascens* Stgr.	Devon, Hants., Warwick north to Ross, from Lapland south in north and central Europe except Belgium and central France, through east Europe to Urals, in the Altai, Amurland, and North America, especially on mountains. Occurs as variety at Cannock Chase, elsewhere in Britain as aberration. Black Forest, French Jura, north Germany, Esthonia, widely spread in north.	August and September.	May and June.	Vaccinium myrtillus and vitis-idæa.	Ledum palustre.	Transitional form being found on moors and on mountains.
ANARTA. *Cordigera* Thnbg.	Forfarshire to Caledonian Canal, north, central and east Europe to Urals and Balkans, in the south of the area on moors in high mountains, Aragon, Amur, Labrador.	May, June,	July and August.	Vaccinium uliginosum.	Arctostaphylos uva-ursi.	
PLUSIA. *Diasema* B. *V. borea* Auriv.	Mountains of central Scandinavia, polar Scandinavia, north Finland, all north Asia, Daurien, Apfel Mountains, Amurland, North Asia. Greenland.	July and August.	Autumn to June.	Vaccinium myrtillus.	Betula nana.	

TABLE II.—*continued*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	REMARKS.
BOMOLOCHA. *Fontis* Thnb.	South England to Suffolk and Merionethshire, south Scandinavia and south Finland through north and central Europe to central Italy, Armenia.	June and July.	August to September.	Vaccinium myrtillus (Spuler).	Erica (Meyrick).	
THALERA. *Putata* L.	Central and north Europe, north Italy, south Russia, and Armenia.	May and June.	July and August.	Vaccinium myrtillus.		Where Bilberry grows (Spuler).
ANAITIS. *Paludata* Thnbg.	Warwick and Staffordshire to Shetlands, Alps, north Germany, Holland and north Europe, Polar Europe and Asia, Labrador.	July.	May to June.	Vaccinium oxycoccus.		
LYGRIS. **Populata* L.	Central and north Europe, north and central Italy, Ural, Siberia and north America, Great Britain and Ireland.	July.	May and June.	Vaccinium myrtillus.	In north on Willow and Poplar (Spuler).	
V. musauaria.	From Musau Alp.					
LARENTIA. *Austriacaria* H. S.	East Alps (Austria) and a variety in the Pyrenees.	June.		Vaccinium.		

LARENTIA. *Incursata* Hb. *V. monticolaria* H. S.	Scandinavia and north Russia, the mountains of Germany and Hungary, the Alps, eastern Siberia and Labrador. Lower Austria and Carinthian Alps.	May, June,	August.	Vaccinium myrtillus and uliginosum.		
LARENTIA. **Cæsiata* Lang. *Ab. annosata* Zett. *Ab. glaciata* Germ. *Ab. gelata* Stgr.	Devon, Gloucester, Wales, north England, Scotland, Shetlands, Ireland, north Europe, German and Hungarian mountains, Alps, north-west Asia and North America. Alps, Lapland, Iceland. Alps, Shetlands, Iceland, Labrador. Iceland.	June and July.	September to May.	Vaccinium myrtillus and vitis-idæa.	Calluna.	
CHLORCLYSTIS. *Debiliata* Hb.	Central Europe, south-north Europe, Urals.	June to August.	May.	Vaccinium myrtillus.		Shady places in woods (Spuler).
ARICHANNA. *Melanaria* L.	North Europe, Alps, north Germany, Bohemia, Mahren, lower Austria, Siberia to Japan.	June, July.	May.	Vaccinium uliginosum.		On moors (Spuler).
EPIONE. *Advenaria* Hb.	In central Europe to south Scandinavia, north Spain, north Italy, south Russia, Armenia to Japan, south England to Stafford and Cambridge.	May, June.	July, August	Vaccinium myrtillus.	Rubus, Salix.	

TABLE II.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plants.	Other Food Plants.	REMARKS.
PYGMÆNA. *Fusca* Thnbg.	High Alps, Scandinavia and Finland.	July, August	Hibernates.	Vaccinium.	Draba and other low plants.	
FIDONIA. *Carbonaria* Cl.	York to Ross, north Europe, Swiss Alps, Riesengebirge and north-east Siberia.	April and May.	July.	Vaccinium.	Erica, Birch, Sallow.	On peaty moors (Spuler).
SELIDOSEMA. *Brunneata* Thnbg.	Perth to Ross, North America, central and north Europe, Pyrenees, north Italy, south Russia, Altai to Japan.	May and June.	July.	Vaccinium myrtillus.		
HYPSIPETES. **Sordidata* F.	Britain to Orkneys, Ireland, north and central Europe, north Asia, Japan, North America.	July, August	April, June.	Vaccinium myrtillus (dark form).	Sallow, Hawthorn.	
ACIDALIA. **Fumata* Stphs. *V. simplaria* Frr. *V. perfumata* Reuter.	Britain to Sutherland, scarce in south, Ireland, north Europe, hilly localities in central Europe, Pyrenees, Alps, Carpathians, Urals. Bavarian Alps. North Sweden and Finland.	May, June.	August, May	Vaccinium myrtillus.	Erica, Orobus niger.	In light clearings of woods with Bilberry undergrowth (Spuler).

METRIOSTOLA. *Vacciniella* Z.	North Germany and Livonia	June.	May.	Vaccinium myrtillus and uliginosum.		
PYRAUSTA. *Nychthemeralis* Hb.	Germany, Switzerland, Hungary and north Europe, local and rare.	June, July.		Vaccinium myrtillus.		
ACALLA. **Maccana* Tr.	Lancashire to Ross, north Ireland, north Europe, northern Germany, Bohemia, Iceland, North America.	August to October.	June.	Vaccinium myrtillus and uliginosum.	Ledum palustre.	In damp woods and on morasses (Spuler).
Lipsiana Schiff.	Lancashire, Westmoreland, Perth, Aberdeen, central Europe (except Holland), west Russia, upper Italy, Castile.	August to April.	July.	Vaccinium vitis-idæa.	Myrica, Pyrus malus, Birch.	
**Schalleriana* L.	Central and north Europe, North America.	June, July, Sept.-April.	May, June.	Vaccinium myrtillus (Spul.).	Symphitum offincinale, Salix.	Boggy places (Spuler).
DICHELIA *Rubicundana* H. S.	Silesian Mountains, Finland, Norway, Lapland.	July and August.	April to June;	Vaccinium myrtillus.		
CHROSES. *Bifasciana* Hb.	West Europe (except Holland), lower Austria, Styria, Salzburg, upper Italy.	May, June, July.	April and May.	Vaccinium myrtillus and uliginosum.		

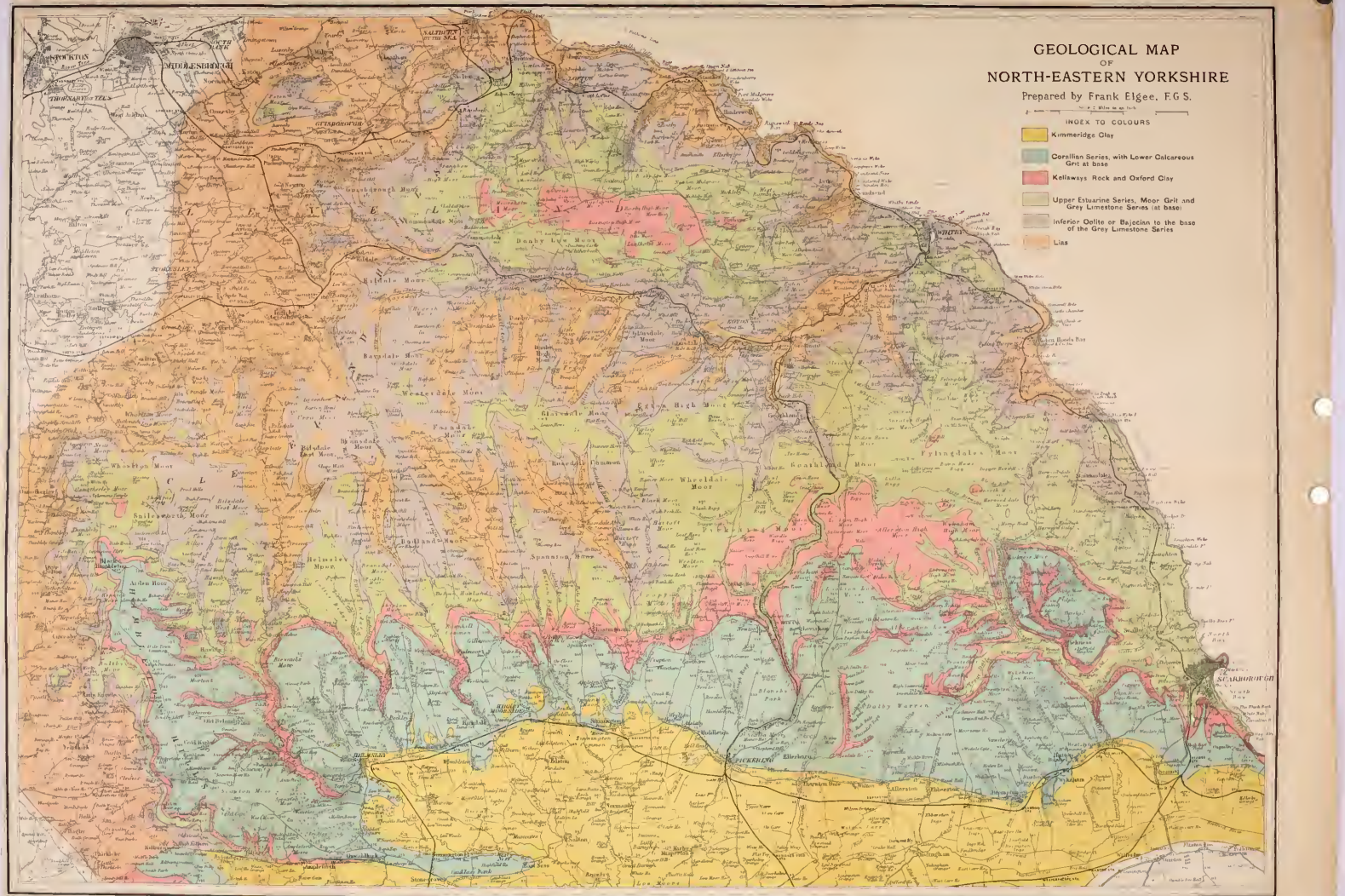
TABLE II.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plans.	Other Food Plants.	REMARKS.
TORTRIX. **Viburniana* F	Britain to the Caledonian Canal, Ireland, central and north Europe, north Spain, upper Italy, Dalmatia.	July.	May, June.	Vaccinium and V. uliginosum	Andr. polifolium, Ledum, Erica, Scrophularia, Lysimachia.	
Rogana Gn.	Alps, Silesia, Siebenbürgen, Hungary.	July and August.	May and July.	Vaccinium myrtillus.		In mountains.
**Rusticana* Tr.	Britain to Shetlands, Ireland, north and central Europe to central Italy, Corsica, Asia Minor.	May and June.	July and August.	Vaccinium myrtillus.	Myrica, Dorycnium, Gentiana amarella Lotus, Convallaria polygonatum.	
ARGYROPLOCE. **Sauciana* Hb.	Kent to Hampshire, Cheshire to York, Perth to Sutherland, south Ireland, central and north Germany, Livonia, Scandinavia, the Alps, upper Italy, Holland.	June.	August and September.	Vaccinium myrtillus.		
**Schulziana* F.	Surrey, Hants., Stafford to Shetlands, north and east Ireland, Alps, Germany, Holland, west Russia, Scandinavia, Lapland.	May to July.	March to May.	Vaccinium.	Between needles of Pinus sylvestris.	In moory localities (Spul.). Common northwards on moors (Meyrick).

Bipunctana F.	Germany, Alps, Galicia, Holland, north-east Europe.	June to August.	April and May.	Vaccinium myrtillus and vitis-idæa.	Alpine Rose.	
OLETHREUTES. *Metallicana* Hb.	Germany, Perth, Jutland, Switzerland, Galicia, Russia, Scandinavia, Siberia.	June, July.	May, June.	Vaccinium myrtillus.	Also probably on other low plants.	
ONARMONIA. *Vacciniana* Z.	England, Aberdeen, east Ireland, north and central Europe.	May, June.	July, August	Vaccinium myrtillus vitis-idæa.	Ledum palustre, Berberis, Cornus.	
RHOPOBOTA. *Naevana* Hb. **V. geminana* Stph.	Britain to Clyde, north and east Ireland, north and central Europe, north Spain, upper and central Italy.	July, August.	May, June.	Geminana, feeds on Vaccinium.	Erica carnea (Spuler), Pyrus, Holly and Blackthorn.	
ANCYLIS. **Myrtillana* Tr.	Britain to Orkneys, north and east Ireland, north and central Europe, mountains of Piedmont.	June.	July, August	Vaccinium myrtillus and uliginosum.	Vicia.	
CYDIA. *Ustomaculana* Curt.	Merioneth, York to Ross, north Europe and northern -central Europe.	June, July.	April to June	Vaccinium myrtillus and vitis-idæa.		
NEPTICULA. *Myrtillela* Stt.	Hereford to Perth, Germany ,Switzerland, Belgium, Sweden.	May, August	July, September, October.	Vaccinium myrtillus.		

TABLE II.—*continued.*

NAME.	DISTRIBUTION.	Time of Appearance.	Time of Larva's Appearance.	Chief Food Plant.	Other Food Plants.	REMARKS.
Weaveri Stt.	Pembroke, York to Perth, central Europe, north German and south German Mountains, Alps, Holland, Sweden, and north-west Russia.	June.	April, May.	Vaccinium vitis-idæa.		
LITHOCOLLETIS. *Junoniella* Z.	Cheshire to Caledonian Canal, north and central Europe.	June, August	April, May, July.	Vaccinium, vitis-idæa.		
GELECHIA. *Infernalis* H. S.	Finland, Scandinavia, Germany, Holland, north Spain, the Alps.	May, June.	April and May.	Vaccinium myrtillus.	Ledum, Birch.	
COLEOPHORA. *Uliginosella* Flek.	North-west Germany.	June.	July to Spring.	Vaccinium myrtillus.		
COLEOPHORA. *Idæella* Hofm.	Germany.	May, June.	July to Spring.	Vaccinium.		
COLEOPHORA. *Vaccinella* H. G.	Germany, Holland, Finland.	May, June.		Vaccinium.		
COLEOPHORA. *Glitzella* Hofm.	Norway, Livonia, England, German Alps.	May, June.		Vaccinium Vitis-idæa.		
COLEOPHORA. *Vitisella* Gregs.	Cheshire, Lancashire, north and central Europe, south French Alps.	June, July.	September to April.	Vaccinium, vitis-idæa.		
INCURVARIA. *Oehlmanniella* Tr.	Scandinavia, central Europe, north Spain, north and central Italy, Dalmatia, south-east Russia, Caucasus.	May, July.	August to April.	Vaccinium.		


GEOLOGICAL MAP
OF
NORTH-EASTERN YORKSHIRE
Prepared by Frank Elgee, F.G.S.
INDEX TO COLOURS
Kimmeridge Clay
Corallian Series, with Lower Calcareous Grit at base
Kellaways Rock and Oxford Clay
Upper Estuarine Series, Moor Grit and Grey Limestone Series (at base)
Inferior Oolite or Bajocian to the base of the Grey Limestone Series
Lias
MIDDLESBROUGH
GUISBOROUGH
WHITBY
SCARBOROUGH
PICKERING
THIRSK
Based upon the Ordnance Survey Maps with the sanction of the Controller of H.M. Stationery Office

MAP SHOWING
THE DISTRIBUTION OF MOORS
IN
NORTH-EASTERN YORKSHIRE
Prepared by Frank Elgee, F.G.S.
The parts coloured are Moors
Based in part upon the Ordnance Survey Maps with the sanction of the Controller of H.M. Stationary Office

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